CHAPTER 4 – SECTION 502
(Superpave Asphaltic Concrete Mixtures)

This chapter describes the procedures and documentation required for designing an asphaltic concrete mixture for use on a DOTD project under Section 502 of the *Standard Specifications* (Superpave Asphaltic Concrete Mixtures). It also details the responsibilities of the Certified Asphaltic Concrete Plant Technician (QC), the DOTD Certified Asphaltic Concrete Plant Inspector and the district laboratory. In addition, several other items are discussed pertaining to definition of lot size, small quantities, JMF resubmittals (rewrites).

MIX DESIGN STEPS AND APPROVAL

Listed below are the general steps required to design, approve and validate an asphaltic mixture according to the Superpave method (Section 502).

- Material procurement and approval (fine aggregate, coarse aggregate, asphalt cement, anti-strip, and other additives)
- Gradation and Bulk Specific Gravity (G_{sb}) determination of aggregates
- Consensus aggregate tests and evaluations (Coarse Aggregate Angularity, Fine Aggregate Angularity, Flat and Elongated Particles, and Sand Equivalency)
- Blending of aggregates to meet specified gradation
- Trial blends with varying asphalt cement contents
- Selection of optimum asphalt cement content
- Dust to Effective Asphalt Cement ratio evaluation
- Moisture sensitivity analysis
- Submittal process and Documentation – (JMF Release Form)
- Approval of JMF Release Submittal
- Validation of JMF Release Submittal
- Final Approval of JMF

1 - Material Procurement and Approval

All samples are to be obtained in accordance with the requirements of the *Materials Sampling Manual*. A DOTD Sample Identification form (or an Aggregate Test Report form) must be completed for each material to be used (Appendix M and AY). Samples should be submitted at **least three weeks prior to the submission of the job mix proposal (JMF). JMF submittals require 7 days for approval.** No proposed JMF will be approved until all mix components have been sampled and approved.

Coarse Aggregate - Coarse aggregates for use in hot-mix asphalt shall be listed in QPL 2. This compilation lists all approved aggregates for use on DOTD projects along with their specific allowable use (hot-mix, concrete, etc.), friction rating, water absorption, Bulk Specific Gravity (G_{sb}), and Source Code.

Coarse aggregate shall comply with Table 502-2 Aggregate Friction Rating. This table specifies allowable usage according to mixture type. The mixture type will be shown on the pavement cross-sections in the contract **plans. (Table 1003-3 shows the friction rating delineation ranges for each type.)** RAP aggregate will be assigned a Friction Rating of III. Table 502-4 lists the minimum amount of crushed coarse aggregates required in each mixture type.

Reclaimed Asphalt Pavement (RAP) - There are no QPL source codes for reclaimed asphalt pavement (RAP). However, these materials must be from approved sources. The DOTD inspector will submit a sample of these materials (taken from the stockpile) to the district laboratory for this approval. Section 502 of the *Materials Sampling Manual* specifies the minimum sample quantity required.

Reclaimed asphalt pavement (RAP), if used along with virgin material, shall meet the specifications of 1003.01(a)(4) and be cold planed in accordance with Section 509 and crushed. The proposed RAP material will be approved for use by the district laboratory engineer prior to use.

Fine Aggregate - Fine aggregates, for use in hot-mix asphalt, shall be approved for use by the district laboratory. DOTD personnel will obtain a sample of fine aggregate (natural sands as defined by Section 1003.06(a)(3)) from a stockpile and submit it to the district laboratory for initial approval and non-QPL source code assignment. Natural sands shall consist of clean, hard, durable, siliceous grains and shall be reasonably free from vegetative matter or other deleterious materials. The district laboratory will determine if the material has less than 25 percent maximum passing the No. 200 sieve in accordance with TR 112 and less than 1.00 percent by weight clay lumps when sampled and tested in accordance with TR 119. Section 502 of the *Materials Sampling Manual* specifies the minimum sample quantity required. This initial source approval will require two to four weeks. The district laboratory, upon approval of the natural fine aggregate source, will provide a source code for the material. These source codes are printed in the DOTD *MATT System Field Handbook*.

Asphalt Cement - Asphalt cement shall also be from an approved source listed in QPL 41. Asphalt cement grade is specified in Table 502-1 – Superpave Asphalt Cement Usage. Currently, LA DOTD allows the use of four performance graded asphalt cements (PG 64-22, PG 70-22m, PG 76-22m and PG 58-28). The specification requirements for these materials are listed in Table 1002-1 of the *Standard Specifications*. Note that PG 76-22m asphalt cement may be substituted for PG 70-22m or PG 64-22 asphalt cements at no increase in price. PG 70-22m asphalt cement may be substituted for PG 64-22 at no increase in price. In addition, when the average daily traffic (ADT) is less than 2500, PG 70-22m Alternate asphalt cement may be substituted for PG 70-22m for Level I and Level A mixtures at no increase in price. When 20 to 30 percent RAP is used, PG 58-28 is required. PG 58-28 may not be substituted for any other asphalt cement.

When mixtures are specified for pavement patching, pavement widening, pavement joint repair, driveway or temporary detour roads, PG 64-22 asphalt cement may be used in lieu of the modified asphalt cements.

If a wearing course is substituted for a binder course, or if a binder course is substituted for a base, the grade of asphalt cement required will be in accordance with the original mixture type shown in the plans and as specified in Table 502-1. A Certificate of Delivery (Appendix O) shall accompany each load delivered to the plant.

Additives – Anti-strip shall be added to all mixtures at a minimum rate of 0.5 percent by weight of asphalt and thoroughly mixed in-line with the asphalt cement at the plant. Anti-strip used shall be listed in QPL 57. Additional anti-strip may be added up to 1.2 percent by weight of asphalt cement. The rate listed on the proposed job mix formula (JMF) shall be 0.1 percent greater than the percentage which will yield a minimum tensile strength ratio (TSR) of 75 percent for mixtures using PG 58-28 or PG 64-22 or a TSR of 80 percent for mixtures using PG 70-22m and PG 76-22m when tested in accordance with AASHTO T 283 with one freeze-thaw cycle. Therefore, the minimum rate that can be listed on the proposed JMF is 0.6 percent. A Certificate of Delivery shall accompany each load of anti-strip. (Appendix Q)

Silicone additives, when needed, shall be from those listed in QPL 22. They shall be dispersed into the asphalt cement by methods and in concentrations given in the QPL list. A Certificate of Delivery shall accompany each load of silicone additives.

Hydrated lime, if used, shall be from a source listed in QPL 34. The minimum rate shall not be less than 1.5 percent by weight of the total mixture. Further, hydrated lime shall be added to and thoroughly mixed with aggregates in accordance with Subsection 503.02.(e). Hydrated lime may be also added as mineral filler. A Certificate of Delivery shall accompany each load of hydrated lime.

Mineral filler, if used, shall be an approved product listed in QPL 10 and shall consist of limestone dust, pulverized hydrated lime (QPL 34), shell dust, Portland cement (QPL 7), or cement stack dust. Mineral dust collected in baghouses or by other dust collectors at asphalt plants is not classified as mineral filler. A Certificate of Delivery shall accompany each load of mineral filler.

2 – Aggregate Bulk Specific Gravity (G_{sb}) and Gradation

Bulk Specific Gravity (G_{sb}) – Once proposed aggregate materials have been stockpiled at the plant and are approved for use (either listed in QPL 2 for coarse aggregate and coarse sand or listed in the Non-QPL Materials Code Section of the *Matt System Field Handbook* for other materials*),* the bulk specific gravity of each mineral aggregate material shall be determined by the Q C technician. The QC technician and department inspector shall jointly obtain two samples for G_{sb} determination from each proposed aggregate stockpile. The QC technician shall test one sample. The DOTD inspector will submit the other sample, along with a Sample Identification Form, to the district laboratory.

The QC technician shall use AASHTO Test Procedure T 84 to determine bulk specific gravity (G_{sb}) and absorption for each proposed fine aggregate source. Note that fine aggregate is defined in the *Standard Specifications* as all material passing the No. 4 sieve.

The QC technician shall use AASHTO Test Procedure T 85 to determine bulk specific gravity (G_{sb}) and absorption for each proposed coarse aggregate source. Note that coarse aggregate is defined in the *Standard Specifications* as all material retained on or above the No. 4 sieve. For aggregate sources which are primarily coarse and contain ten percent or less material by weight passing the No. 4 sieve, a bulk specific gravity (G_{sb}) determination on that passing portion will not be required. However, should the proposed aggregate stockpile contain more than ten percent passing the No. 4 sieve, then the finer portion shall be separated and tested in accordance with AASHTO T 84. The results, for both coarse and fine portions, shall then be mathematically combined in proportion to the amounts retained on the No. 4 and passing the No. 4 to produce a single G_{sb} value for the source. The bulk specific gravity (G_{sb}) is used to calculate VMA and asphalt absorption. False high values for G_{sb} will lead to high VMA's and negative absorptions. If negative absorptions are calculated, the G_{sb} is in error. The DOTD inspector is to notify the district laboratory engineer.

The contractor may use the calculated values for bulk specific gravity (G_{sb}) on the proposed JMF provided that they are within the following range when compared to the district laboratory's values. These values were determined from multi-laboratory precision analysis.

Multi-Laboratory Precision for Bulk Specific Gravity (G_{sb})	
	G_{sb}
Fine Aggregate	±0.035
Coarse Aggregate	±0.020

Should the contractor's values be outside this range when compared to the district laboratory, then both parties shall jointly run a third test whose results shall be used for volumetric calculations on the proposed JMF submittal.

Bulk specific gravity values agreed upon by this procedure may be used on subsequent job mix formula submittals. However, the bulk specific gravity (G_{sb}) may be retested at either party's request. If bulk specific gravity (G_{sb}) results of the retest are within the tolerances shown above when compared to the previously determined values, the QC technician has the option of using the new values or the ones previously established and used on approved, validated JMF's.

At the option of the contractor/producer or DOTD, if the proposed composite aggregate blend is already known, the bulk specific gravity (G_{sb}) may be performed on a composite belt sample, separating the fine and coarse portions, in lieu of performing the G_{sb} procedure on each individual aggregate.

NOTE

The effective specific gravity, G_{se} of the RAP aggregate will be used in lieu of G_{sb}.

To determine G_{se}, first measure G_{mm} in accordance with AASHTO T209. Then perform an extraction in accordance TR 323 to measure AC content.

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}},$$

where: P_b is the % AC and G_b is the specific gravity of the AC assumed to be 1.03.

Gradation – The QC technician shall obtain a second sample from each proposed stockpile for gradation determination. An accurate gradation analysis is required for blending analysis and to determine consistency of incoming material.

It is recommended that the QC technician secure samples of all bulk shipments of aggregates delivered to the plant site. The gradation results of these shipments should be determined prior to their addition to a working stockpile. Documentation of these continuous stockpile gradation and specific gravity results shall be kept on file so that varying trends of the aggregate source may be determined.

Under Subsection 109.07 of the *Standard Specifications*, the department may allow advanced payment to a producer for stockpiled materials stored in excess of 90 calendar days for use on a DOTD project. To make a request for advanced payments, the contractor/producer shall provide the project engineer with a written detailed description of the material, its intended use, and location. Refer to the section on Dedicated Stockpiles in this manual. When inspecting and testing aggregates, a certified technician should be cognizant of proper bulk material handling. Quality control of hot-mix asphalt, regardless of plant type, begins with proper stockpile management.

Aggregates must be handled in a manner that will not be detrimental to the final mixture. Stockpiles shall be built in a manner that will not cause segregation. Segregation can be minimized if stockpiles are built in successive layers, not in a conical shape. Constructing stockpiles in layers enables different aggregate fractions to remain evenly mixed and reduces the tendency of large aggregates to roll to the outside and bottom of the pile. Stockpiles shall be located on a clean, stable, well-drained surface to ensure uniform moisture content throughout the stockpile. The area in which the stockpiles are located shall be large enough for the stockpiles to be separated, so that no intermixing of materials will occur. Stockpiles shall not become contaminated with deleterious materials such as clay balls, leaves, sticks or nonspecification aggregates. The materials shall not become contaminated nor segregated when they are transported from stockpiles to cold bins. Aggregates are often moved from stockpile to cold bin with a front-end loader. The operator should proceed directly into the stockpile, load the bucket and move directly out. He should not scoop aggregate from only the outside edges of the stockpile.

3 – Consensus Aggregate Test Evaluations

The consensus aggregate tests are those whose results have been correlated with well performing HMA pavements. The consensus tests are listed below:

- Coarse Aggregate Angularity (DOTD TR 306 – Double Face)
- Fine Aggregate Angularity (DOTD TR 121)
- Flat and Elongated Count (ASTM D 4791)
- Sand Equivalency (DOTD TR 120)

There are required standards for these aggregate properties. They are listed in Table 502-4 – Superpave Design, Control and Acceptance Limits. They are based on traffic level and position within the pavement structure. Materials near the pavement surface subjected to high traffic levels require more stringent consensus standards. **They are intended for application to a proposed aggregate blend, not to individual components.** However, they may be run on individual aggregate sources and mathematically combined. The composite is reported on the JMF. Individual components may be tested so that poor materials may be identified.

Coarse Aggregate Angularity (CAA) is determined in accordance with TR 306 (Double Faced) on the coarse material retained on the No. 4 sieve. This test ensures a high degree of aggregate internal friction and rutting resistance. The minimum values for this test are given in Table 502-4 for each Level type and nominal maximum aggregate size (NMS). Although the individual source coarse aggregate angularity (CAA) is reported on the JMF, the CAA determined from the composite blend, retained on the No. 4 sieve, shall govern for JMF acceptance. The Q C technician shall determine this CAA composite value (and for any individual source values, if necessary) and report it on the JMF submittal.

The district laboratory will verify the CAA value. Should the district laboratory's results be within ±3 percent of the result reported on the JMF and be within specification limits, then the QC Technician's result may be used. If not, the QC technician shall run a third sample jointly with the district laboratory engineer's representative. The QC technician shall use this jointly determined value for JMF submittal.

Fine Aggregate Angularity (FAA) is determined in accordance with DOTD TR 121 using the bulk specific gravity of the combined sieves. (Note that the bulk specific gravity used in this procedure may be obtained by DOTD TR 300, Method E, Bulk Specific Gravity (G_{sb}) and Absorption of Fine Aggregates.) This property ensures a high degree of fine aggregate internal friction and rutting resistance. Higher void content means more fractured faces. The minimum values for this test are given in Table 502-4 for each level type and NMS size.

The fine aggregate angularity (FAA) of the composite mixture shall be determined by calculating the weighted average based on aggregate proportions and the individual FAA values reported on the JMF. Aggregate sources that have 10% or less passing the No. 4 sieve shall not be tested individually for fine aggregate angularity. When individual aggregate sources having more than 10% retained on the No. 4 sieve do not have sufficient quantities of any of the required sieve sizes listed in Method A of AASHTO 304, a composite sample of the proposed JMF blend shall be tested. The fine aggregate materials tested for FAA shall be tested in accordance with DOTD TR 121, washed over the No. 100 sieve. The QC technician shall determine this FAA composite value (and for any individual source values, if necessary) and report it on the JMF submittal.

The district laboratory will verify this value. Should the district laboratory's results be within ±2 percent of the result shown on the JMF and be within specification limits, then the QC technician's result may be used. If not, the contractor/producer shall then run a third sample jointly with the district laboratory engineer's representative. The QC technician shall use this jointly determined value for JMF submittal.

Flat and Elongated Count (FE) is determined in accordance with ASTM D 4791 using the coarse aggregate portion retained on the No. 4 sieve. This characteristic is the percentage by weight of coarse aggregates that have a maximum to minimum dimension greater than five. Elongated particles are undesirable because they have a tendency to break during construction and under traffic. The minimum values for this test are given in Table 502-4 for each level type and NMS size.

Although the individual source results for flat and elongated particles are reported on the JMF, the (FE) determined from the composite blend, retained on the No. 4 sieve, shall govern for JMF acceptance. The QC technician shall determine this (FE) composite value. The district laboratory will verify this value. Should the district laboratory's results be within ±1 percent of the result shown on the JMF and be within specification limits, then the contractor/producer's result may be used. If not, the contractor/producer shall run a third sample jointly with the district laboratory engineer's representative. The QC technician shall use this jointly determined value for JMF submittal.

Sand Equivalency (SE), sometimes referred to as clay content, is determined in accordance with TR 120, the fine aggregate portions of the composite blend (natural sands only) passing the No. 4 sieve. Clay content is the percentage of clay material contained in the aggregate fraction passing the No. 4 sieve.

Sand equivalency requirements shall apply to individual natural sand sources only and do not apply to manufactured fines or fines produced from crushing operations (e.g., screenings, No. 10's and No. 11's). The minimum values for this test are given in Table 502-4 for each level type and NMS size.

For example, if the JMF lists 30 percent No. 11's (manufactured sand), 10 percent coarse sand, and 5 percent natural sand (fine sand), then the SE sample would be prepared by combining 67 percent coarse sand and 33 percent natural or fine sand. No screenings (No. 11's) would be used in preparing the SE sample.

The contractor/producer shall determine the SE composite value (and for any individual source values, if necessary) and report it on the JMF submittal. The district laboratory will verify this value. The district lab's results must meet specification limits. If not, the contractor/producer shall then run a third sample jointly with the district laboratory engineer's representative. The QC technician shall use this jointly determined value for JMF submittal.

4 – Blending Aggregates to Meet Specified Gradation

Following bulk specific gravity determinations, gradation and aggregate consensus tests analysis, the technician must determine a master composite blend of the proposed, approved aggregates. Again, the mixture type shall be determined from the typical sections in the project plans. The specific gradation requirements for each mixture type are listed in Tables 502-3 and 502-5 in the *Standard Specifications*.
Table 502-3 lists a nominal maximum size aggregate for each type, a specification gradation limit for each mixture type, and a tolerance (plus and minus) for the proposed JMF blend.

Section 502 specifies four different nominal maximum size mixtures, 1/2 inch (12.5 mm), ¾ inch (19.0 mm), 1.0 inch (25.0 mm) and 1 ½ inch (37.5 mm). The following definitions are used by the DOTD to determine these sizes:

- **Nominal Maximum Size (NMS) – One sieve size larger than the first sieve to retain more than 10 percent by weight of the combined aggregates.**

- **Maximum Size (MS)– One sieve size larger than the nominal maximum size.**

Table 502-5 lists the gradation control points and restricted zone boundary for each nominal maximum size mixture.

With the mixture type known, the QC Technician can begin to mathematically blend the proposed aggregates to meet the requirement of Tables 502-3 and 502-5. An approved computer spreadsheet may be used for this task.

Table 502-4 – Superpave Design, Control and Acceptance specifies that a maximum of 15 percent natural sand be used in all Superpave mixtures with the exception of the 12.5 mm Level A used for Incidental Paving. Incidental paving may be used for pavement wearing course, airports, joint repair, leveling, driveways, turnouts, crossovers, detour roads and other incidental items **approved by the project engineer.**

Once the aggregates have been mathematically blended to meet requirements of Section 502, the composite gradation is plotted on the appropriate *Asphaltic Concrete Gradation – 0.45 Power Curve* for the corresponding nominal maximum aggregate size (Appendices O, P and Q). The 0.45 power curve uses a unique graphing technique to show the cumulative particle size distribution of an aggregate blend. The ordinate (vertical axis) of the chart is percent passing. The abscissa (horizontal axis) is an arithmetic scale of sieve size, raised to the 0.45 power. On these charts, the maximum density grading for a particular maximum size corresponds to a straight line drawn from the origin to the selected maximum aggregate size. It must be noted that this **maximum density line** is approximate, but can serve as a useful reference in proportioning aggregates.

These power curves also depict two other features, which are specified in Table 502-5. The **control points** function as specification limits through which the composite gradation must pass. The **restricted zone** occurs along the maximum density gradation. The restricted zone was originally introduced as a guide to ensure that mixtures would have sufficient voids in the mineral aggregate (VMA) to allow for sufficient asphalt cement for durable pavements. Another purpose of the restricted zone was to restrict the amount of natural sand in the mixture. Aggregates with excessive amounts of natural sand produce tender HMA mixes. However, some aggregate gradations that pass through the restricted zone provide mixes that perform very well in service. See Table 502-5 for guidance on mixtures that go through this zone of the 0.45 power curve.

Further, LA DOTD allows for all mixtures produced under Section 502 to be either on the coarse or the fine side. A coarse side gradation refers to one, that falls below the restricted zone. Conversely, a fine side blend is one that would be drawn above the restricted zone. A coarse and fine side gradation plot on the 0.45 power curve is shown in Figure 4-1

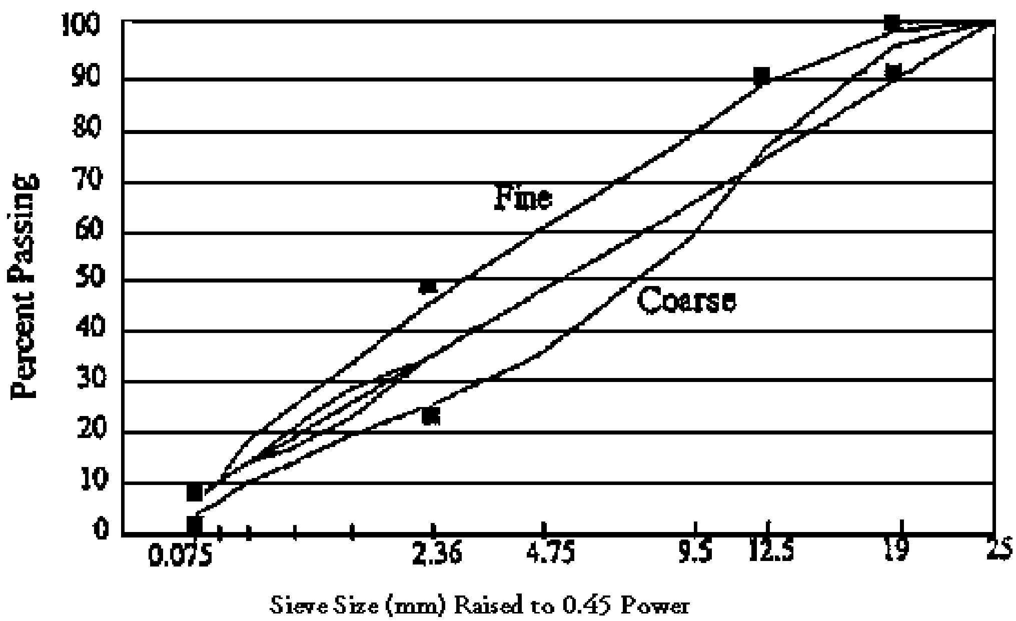

Figure 4-1 – 0.45 Power Curve with Coarse and Fine Sided Gradations.

Care should be given in the selection of the final composite aggregate blend. Many coarse graded blends may, if not properly designed and compacted, lead to pavements that are very porous and allow water to permeate the base and subbase.

Following is an example of the gradation requirements and a typical fine side proposed composite gradation Superpave Level 1 (3/4 inch - 19.0mm NMS):

Sieve Size	Control Points	Restricted Zone	Mix Tolerance	Proposed JMF	JMF Limits
1.0 inch	100		± 4	100	100
¾ inch	90 – 100		± 4	94	90 – 98
½ inch	89 max		± 4	83	79 – 87
3/8 inch			± 4	73	
No. 4			± 4	54	
No. 8	23 – 49	35	± 3	42	39 – 45
No. 16		22 – 28	± 2	36	
No. 30		17 – 21	± 2	29	
No. 50		14	± 2	17	
No. 100			± 2	10	
No. 200	2.0 – 8.0		± 0.7	4.8	4.1 – 5.5

Note that the mix tolerances are applied to the proposed JMF to determine the allowable upper and lower limit. For gradation purposes, all values are reported to the nearest whole number with the exception of the No. 200 sieve size, which is rounded to the nearest tenth.

5 – Trial Blends with Varying Asphalt Cement Contents

The QC technician, following determination of the composite aggregate blend, shall prepare trial blends of hot-mix asphalt with varying percentages of asphalt cement. These trial blends may be produced either in the design laboratory or the HMA plant. (Remember only hot-mix produced from a certified plant and with an approved JMF will be allowed on a DOTD project.)

The type asphalt cement to be used is stipulated in Table 502-1 – Superpave Asphalt Cement Usage. Note the following:

- When mixtures are specified for pavement patching, pavement widening, pavement joint repair, driveways, or temporary detour roads, PG 64-22 asphalt cement may be used in lieu of the modified asphalt cement.

- Leveling courses shall use the same grade of asphalt cement as in the layer immediately above, except when the project engineer directs blade leveling, a PG 64-22 will be allowed.

- PG 76-22m asphalt cement may be substituted for PG 70-22m or PG 64-22 asphalt cements at no increase in price. PG 70-22m asphalt cement may be substituted for PG 64-22 at no increase in price. When average daily traffic (ADT) is less than 2500, PG 70-22m Alternate asphalt cement may be substituted for PG 70-22m asphalt cement for Level I and Level A mixtures at no increase in price.

- If a wearing course is substituted for a binder course, or if a binder course is substituted for a base, the grade of asphalt cement required will be in accordance with the original mixture type shown in the plans and as specified in Table 502-1.

- When 20 to 30 percent RAP is used, PG 58-28 asphalt cement is required.

The QC technician shall prepare three trial blends with the proposed composite aggregate blend. One of the blends shall be prepared at an asphalt cement content near optimum (as defined by a specified air void content, V_a). A second trial blend shall be prepared at an asphalt cement content approximately 0.5% less than optimum. A third trial blend shall be prepared at an asphalt cement content approximately 0.5% greater than optimum. A minimum of two specimens shall be prepared at each of the trial asphalt cement contents.

The mixing and compaction temperature used for preparing the trial mixes shall be determined by the asphalt cement supplier and will be printed on the Certificate of Delivery that accompanies each transport of asphalt cement delivered to the plant. (The traditional method of determining asphalt cement mixing and compaction temperatures, via a temperature and viscosity chart, is not valid for many of the polymer-modified asphalts now in use.)

Unless procedures require otherwise, the laboratory produced mix shall be cured 2 hours in the mold and plant produced mix shall be cured 1 hour in the mold at the compaction temperature (±10°F). When the aggregate water absorption is >2%, the oven aging time for plant-produced mix shall be increased to 2 hours.

Once the trial blends have been prepared, each specimen (briquette) shall be tested for the following:

1. Bulk Specific Gravity, G_{mb} at N_{design}
2. Air Voids, V_a at N_{design}
3. Voids in Mineral Aggregate, VMA at N_{design}
4. Voids Filled with Asphalt, VFA at N_{design}
5. Percent G_{mm} at $N_{initial}$
6. Percent G_{mm} at N_{design}
7. Percent G_{mm} at N_{max}

In addition, a loose mix sample from each trial blend asphalt cement content shall be prepared and tested for maximum theoretical specific gravity, G_{mm} (Rice Gravity) using AASHTO T209. **For laboratory produced trial blends, the mixture, when tested for G_{mm}, shall be cured at compaction temperature for approximately two hours prior to specimen preparation. Plant produced trial blends require one hour curing or aging period.** The average of the test values for the two specimens at each asphalt content shall be averaged to report a single value.

The department, for use when analyzing and documenting Superpave hot-mix asphalt mixtures, adopts the following definitions and nomenclature. Mineral aggregate is porous and can absorb water and asphalt to a variable degree. Furthermore, the ratio of water to asphalt absorption varies with each aggregate. The three methods of measuring aggregate specific gravity take these variations into consideration. The methods are bulk, apparent, and effective specific gravities. The differences among the specific gravities come from different definitions of aggregate volume Bulk Specific Gravity, $G_{sb,}$ the ratio of the weight in air of a unit volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature to the weight in air of equal density of an equal volume of gas-free distilled water at a stated temperature. See Figure 4-2

- Apparent Specific Gravity, G_{sa} – The ratio of the weight in air of a unit volume on an impermeable material at a stated temperature to the weight in air of equal density of an equal volume of gas-free distilled water at a stated temperature. See Figure 4-2.

- Effective Specific Gravity, G_{se} – The ratio of the weight in air of a unit volume of a permeable material (excluding voids permeable to asphalt) at a stated temperature to the weight in air of equal density of an equal volume of gas-free distilled water at a stated temperature. See Figure 4-2.

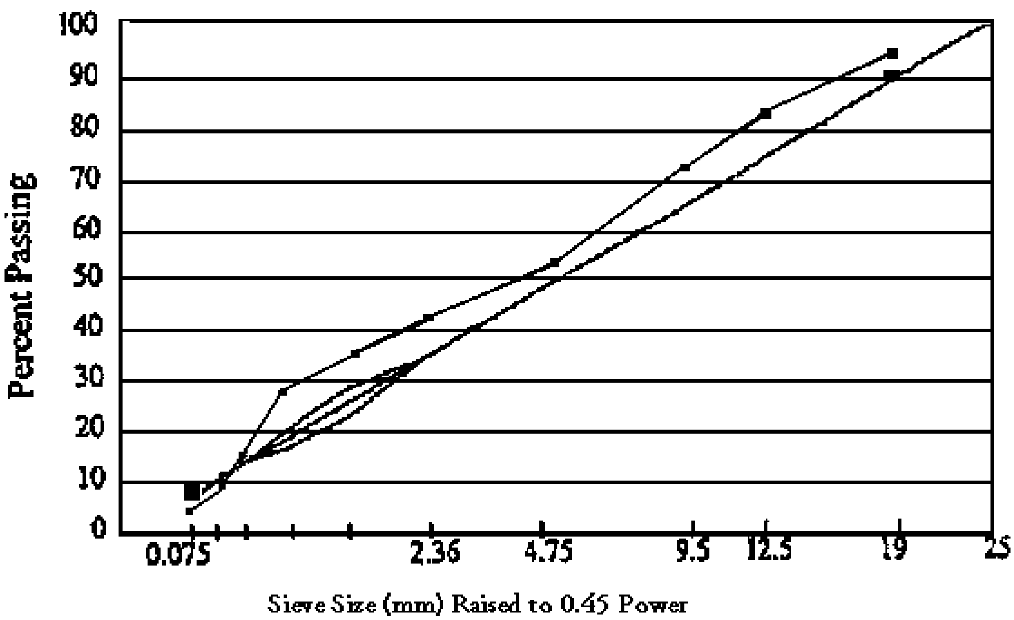

Figure 4-2 – Illustrating Bulk, Effective and Apparent Specific Gravities, Air Voids, and Effective Asphalt Content in Compacted Asphalt Paving Mixture

- Voids in Mineral Aggregate, VMA – The volume of intergranular void space between the aggregate particles of a compacted paving mixture that includes the air voids and the effective asphalt content, expressed as a percent of the total volume of the sample. See Figure 4-3.

- Air Voids, V_a – The total volume of the small pockets of air between the coated aggregate particles throughout a compacted paving mixture, expressed as a percent of the bulk volume of the compacted paving mixture. See Figure 4-3.

- Voids Filled with Asphalt, VFA – The portion of the volume of intergranular void space between the aggregate particles (VMA) that is occupied by the effective asphalt. See Figure 4-3.

- Effective Asphalt Content, P_{be} – The total asphalt content of a paving mixture minus the portion of asphalt that is lost by absorption into the aggregate particles. See Figure 4-3.

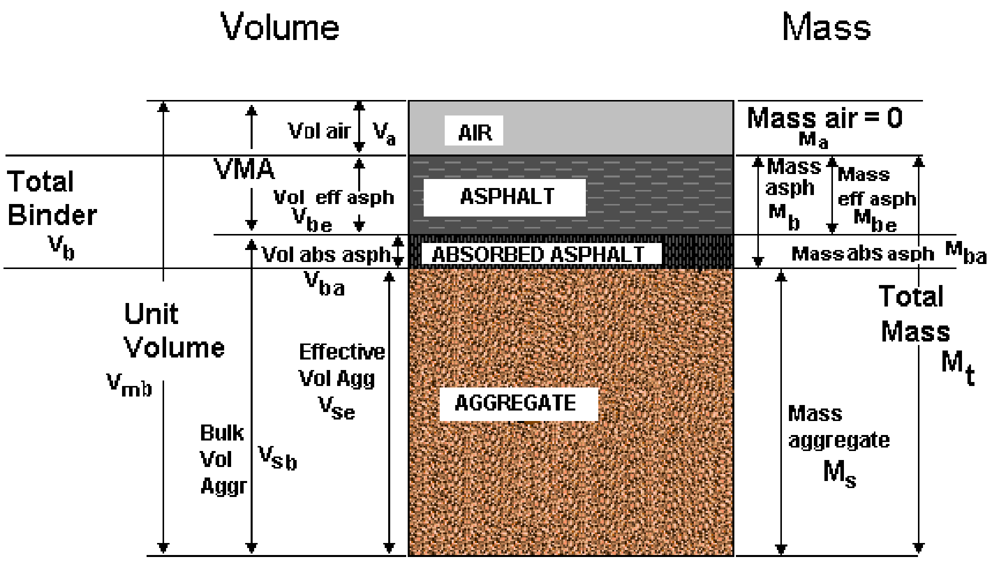

Figure 4-3 – Representation of Volumes in a Compacted Asphalt Specimen (Phase Diagram)

- Asphalt Cement Specific Gravity, G_b – The ratio of the mass in air of a given volume of asphalt binder to the mass of an equal volume of water, both at the same temperature.

- Mixture Bulk Specific Gravity, G_{mb} – The ratio of the mass in air of a given volume of compacted HMA to the mass of an equal volume of water, both at the same temperature.

- Theoretical Maximum Specific Gravity, G_{mm} (Rice Gravity) – The ratio of the mass of a given volume of HMA with no air voids to the mass of an equal volume of water, both at the same temperature.

- Initial Number of Gyrations, $N_{initial}$ - This is the number of gyrations (7, 8 or 9 gyrations) that represents a measure of mixture compactability. Mixtures that compact too quickly are believed to be tender during construction and may be unstable when subjected to traffic. A mix that has 4 percent voids at N_{design} should have at least 11 percent air voids (9.5 percent for Level I mixes and 8.5 percent for Level A mixes) at $N_{initial}$. Mixtures that tend to fail this requirement are often finer mixtures.

- Design Number of Gyrations, N_{design} - This is the number of gyrations required to produce a density in the mix that is equivalent to the expected density in the field after the indicated amount of traffic. In the mix design process, an asphalt content is selected that will provide 4 percent air voids when the mix is compacted to N_{design} gyrations.

- Maximum Number of Gyrations, N_{max} - This is the number of gyrations required to produce a density in the laboratory that would never be exceeded in the field. N_{design} provides an estimate of the ultimate field density. N_{max} provides a compacted density with some safety factor to ensure that the mixture does not densify too much, which would result in low in-place air voids, which can cause rutting. The air voids at N_{max} are required to be at least 2 percent. Mixtures that have less than 2 percent air voids at N_{max} are believed to be more susceptible to rutting than mixtures exceeding 2 percent air voids.

The following standard conventions are used to abbreviate asphalt cement (binder), aggregate and mixture characteristics:

Specific Gravity (G) – G_{xy}

x - b = binder
s = aggregate (for example, stone)
m = mixture

y - b = bulk
e = effective
a = apparent
m = maximum theoretical

Mass (P) or Volume (V) Concentration: P_{xy} or V_{xy}

x - b = binder
s = aggregate (for example, stone)
a = air

y - e = effective
a = absorbed

Here is Superpave nomenclature related to volumetric calculations:

Superpave Definitions

G_{mb} = bulk specific gravity of the compacted HMA specimen.

G_{mm} = maximum specific gravity of the paving mixture (no air voids)

G_b = specific gravity of the asphalt

G_{se} = effective specific gravity of the aggregate

G_{sb} = bulk specific gravity of the aggregate

V_a = air voids in the compacted mixture, percent of total volume

VMA = voids in the mineral aggregate, percent of bulk volume.

VFA = voids filled with asphalt, percent of VMA

P_s = aggregate content, percent by total mass of the mixture

P_b = asphalt content, percent by total mass of the mixture

P_{ba} = absorbed asphalt, percent by mass of the aggregate

P_{be} = effective asphalt content, percent by total mass of the mixture

P_{200} /P_{be} = dust to asphalt ratio

P_{200} = aggregate content passing the N0. 200 sieve, percent by mass of aggregate

The VMA values for compacted asphalt paving mixtures are to be calculated in terms of the bulk specific gravity (G_{sb}) of the combined aggregate.

Voids in the mineral aggregate (VMA) and air voids (V_a) are expressed as percent by volume of the paving mixture. Voids filled with asphalt (VFA) is the percentage of VMA that is filled by the effective asphalt cement. The effective asphalt cement content shall be expressed as a **percent by weight of the total weight of the mixture.**

The following equations are used to compute the volumetric properties of compacted hot-mix asphalt specimens:

Bulk Specific Gravity of HMA Specimen G_{mb}

$$\mathrm{Gmb} = \frac{\text{Weight in Air}}{\text{SSD Weight} - \text{Weight in Water}}$$

Air Voids, V_a:

$$V_a = 100 \times \frac{G_{mm} - G_{mb}}{G_{mm}}$$

Voids in Mineral Aggregate, VMA:

$$\mathrm{VMA} = 100 - \frac{G_{mb} \times P_s}{G_{sb}}$$

Voids Filled with Asphalt, VFA:

$$VFA = 100 \times \frac{VMA - V_a}{VMA}$$

Effective Specific Gravity, G_{se}:

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

Percent Absorbed Asphalt, P_{ba}:

$$P_{ba} = \frac{(100 \times G_b)(G_{se} - G_{sb})}{G_{sb} \times G_{se}}$$

Percent Effective Asphalt Cement, P_{be}:

$$P_{be} = P_b - \frac{P_{ba} \text{ x } P_s}{100}$$

Dust to Asphalt Ratio, D/P or P_{200}/P_{be}:

$$\text{Dust Ratio} = \frac{P_{200}}{P_{be}}$$

Slope of Gyratory Compaction Curve:

$$\text{Slope} = \frac{(\%G_{mm} @ N_{des} - \%G_{mm} @ N_{initial})}{(\log(N_{des}) - \log(N_{initial}))}$$

The Superpave volumetric analysis results for the trial blends shall be documented on a computer generated spreadsheet or a similar DOTD supplied form.

The following relationships, as determined from these equations, shall also be plotted on the Department's *Optimum Asphalt Cement Content Summary of Test Properties* or an approved similarly designed graph.

1. Air Void (V_a) versus asphalt content
2. Voids in Mineral Aggregate (VMA) versus asphalt content
3. Voids Filled with Asphalt (VFA) versus asphalt content
4. Percent G_{mm} at $N_{initial}$
5. Percent G_{mm} at N_{design}.

6 – Selection of Optimum Asphalt Cement Content

Examining the test property curves plotted on the department's *Optimum Asphalt Cement Content Summary of Test Properties*, reveals information about the sensitivity of the mixture to asphalt content. Trends generally noted are:

- The percent air voids (V_{a},) steadily decreases with increasing asphalt cement content, ultimately approaching a minimum void content.

- The percent voids in the mineral aggregate (VMA) generally decreases to a minimum value then increases with increasing asphalt cement content.
- The percent voids filled with asphalt (VFA) steadily increase with increasing asphalt cement content because VMA is being filled with asphalt cement.

- The percent G_{mm} at $N_{initial}$ increases with increasing asphalt cement content.

- The percent G_{mm} at N_{design} consistently increases with increasing asphalt cement content.

The design asphalt cement content of the mixture is selected at that percentage yielding the median percentage of the range of air voids (which is 4.0 percent for all Superpave mixtures). In addition, all of the calculated and measured mix properties at this asphalt cement content should then be evaluated and compared to the specified values in Table 502-4. If all of the design criteria are not met, then some adjustment is necessary or the mix may need to be redesigned.

The following discussion pertaining to VMA, V_a and VFA is reprinted here from MS-2 to provide assistance and understanding to the technician in adjusting mixtures to meet these volumetric properties:

> *EVALUATION OF VMA CURVE: In many cases, the most difficult mix design property to achieve is a minimum amount of voids in mineral aggregate. The goal is to furnish sufficient space for the asphalt cement so it can provide adequate adhesion to bind the aggregate particles, but without bleeding when temperatures rise and the asphalt expands. Normally, the curve exhibits a flattened U-Shape, decreasing to a minimum value and then increasing with increasing asphalt content.*

This dependency of VMA on asphalt cement content appears to be a contradiction to the definition. One might expect the VMA to remain constant with varying asphalt cement content, thinking that the air voids would simply be displaced by asphalt cement. In reality, the total volume changes across the range of asphalt contents; the assumption of a constant unit volume is not accurate. With the increase in asphalt, the mixture actually becomes more workable and compacts more easily, meaning more weight can be compressed into less volume. Therefore, up to a point, the bulk density of the mixture increases and the VMA decreases.

At some point, as the asphalt cement content increases (the bottom of the U-Shaped curve) the VMA begins to increase because relatively more dense material (aggregate) is displaced and pushed apart by the less dense material (asphalt cement). It is recommended that ***asphalt cement contents on the wet or right-hand increasing side of this VMA curve be avoided****, even if the minimum air void and VMA criteria is met. Design asphalt cement contents in this range have a tendency to bleed and/or exhibit plastic flow when placed in the field. Any amount of additional compaction from traffic leads to inadequate room for asphalt expansion, loss of aggregate-to-aggregate contact, and eventually, rutting and shoving in high traffic areas. Ideally, the design asphalt cement content should be selected slightly to the left of the low point of the VMA curve, provided none of the other mixture criteria are violated.*
In some mixtures, the bottom of the U-Shaped VMA curve is very flat, meaning that the compacted mixture is not as sensitive to asphalt cement content in this range as some other factors. In the normal range of asphalt contents, compactability is influenced more by aggregate properties. However, at some point the quantity of asphalt will become critical to the behavior of the mixture and the effect of asphalt will dominate as the VMA increases drastically.

When the bottom of the U-Shaped VMA curve falls below the minimum criteria level required for the nominal maximum aggregate size of the mix, this is an indication that changes to the job-mix formula are necessary. Specifically the aggregate grading should be modified to provide additional VMA. ***The design asphalt cement content should not be selected at the extremes of the acceptable range even though the minimum criteria are met.*** *On the left-hand side, the mix would be too dry, prone to segregation, and would probably be too high in air voids. On the right-hand side, the mix would be expected to rut.*

If the minimum VMA criteria are completely violated over the entire asphalt cement content range (curve is completely below the specified minimum), a significant redesign and/or change in material sources is warranted.

EFFECT OF AIR VOIDS: It should be emphasized that the design range of air voids (3 to 5 percent) is the level desired after several years of traffic. This goal does not vary with traffic; the laboratory compactive effort is supposed to be selected for the expected traffic. This design air void range will normally be achieved if the mixture is designed at the correct compactive effort and the percent air voids after construction is about 8 percent. Some consolidation with traffic is expected and desired. The consequence of a change in any factor or any detour in the procedure that offsets the total process will be a loss of performance or service life. It has been shown that ***mixtures that ultimately consolidate to less than three percent air voids can be expected to rut and shove*** *if placed in heavy traffic locations. Several factors may contribute to this occurrence, such as an arbitrary or accidental increase in asphalt cement content at the mixing facility or an increased amount of ultra-fine particles passing the No. 200 sieve beyond that used in the laboratory, which will act as an asphalt cement extender.*

Similarly, problems can occur if the final air void content is above five percent or if the pavement is constructed with over eight percent air voids initially. Brittleness, premature cracking, raveling and stripping are all possible under these conditions.

The overall objective is to limit adjustments of the design asphalt cement content to less than 0.5 percent air voids from the median of the design criteria (4 percent for all mixtures), especially on the low side of the range and to verify that the plant mix closely resembles the laboratory mixture.

EFFECT OF VOIDS FILLED WITH ASPHALT: Although VFA, VMA and V_a are all interrelated and only two of the values are necessary to solve for the other, including the VFA criteria helps prevent the design of mixes with marginally-acceptable VMA. The main effect of the VFA criteria is to limit maximum levels of VMA, and, subsequently, maximum levels of asphalt cement content.

VFA also restricts the allowable air void content for mixes that are near the minimum VMA criteria. Mixes designed for lower traffic volumes will not pass the VFA criteria with a relatively high percent air voids (five percent) even though the air void criteria range is met. The purpose is to avoid less durable mixtures in light traffic situations.

Mixtures designed for heavy traffic will not pass the VFA criteria with relatively low percent air voids (less than 3.5 percent) even though that amount of air voids is within the acceptable range. Because low air void contents can be very critical in terms of permanent deformation, the VFA criteria helps to avoid those mixes that would be susceptible to rutting in heavy traffic situations.

The VFA criteria provide an additional factor of safety in the design and construction process in terms of performance. Since changes can occur between the design stage and actual construction, an increased margin for error is desirable.

One of the most common problems when designing a Superpave HMA mixture is providing sufficient VMA. Lack of VMA can lead to inadequate space for sufficient asphalt cement. If all other factors remain constant, the fine aggregate fractions contribute more to VMA than the coarse aggregate fractions. However, the addition of natural sand to increase VMA is strongly discouraged and may violate the specifications should the maximum natural sand limit be surpassed. The rounded particles in natural sand, which include more inherent void space than manufactured, angular fine fractions, may also allow compaction to occur more easily and thoroughly. This can lead to a decrease in VMA, defeating the intended purpose.

The filler material (particles passing the No. 200 sieve) is the aggregate fraction with the highest VMA due to its large surface area. These VMA values have been reported to be as high as 32 percent. However, because of the wide variety of shapes and sizes found in these particles, adding more of these fines to the mixture can produce different VMA results. In some cases, the extremely fine particles (less than 10 microns) may function as an asphalt cement extender, which would effectively cause the available VMA to decrease, not increase as desired.

VMA increases can be achieved by an overall adjustment of the gradation or possibly changing the shape or texture of the intermediate portion of the blended aggregates. Because of the interaction of the two factors on the packing characteristics of an HMA mixture, gradation changes (typically moving away from the maximum density line) are only reasonable with the same aggregate source. By adjusting the proportional percentages of the aggregates that substantially contribute to the intermediate sizes, the gradation curve can be revised to plot further away from the maximum density line. This shift will, in most cases, increase VMA. Extreme care, however, should be taken when shifting away from the maximum density line for coarse graded mixtures. An excessive shift may produce a very coarse, gap-graded blend that will lead to compaction and permeability problems.

Particle shape and texture can also make a difference. Changing the source of one aggregate may introduce a completely new interaction between all of the other aggregate particles. Specifically, changing the angular shape and texture of coarse aggregates by crushing or switching from natural sands to more angular manufactured sands (or screenings), can implement a significant change in VMA. The same aggregate gradation with the same compaction effort, but with different shaped particles, can produce, in most cases, a different amount of VMA.

7 – Dust to Effective Asphalt Cement Ratio Evaluation

Another mixture requirement, as per Table 502-4, is the dust ratio. This is computed as the ratio of the percentage by weight of aggregate finer than the No. 200 sieve to the effective asphalt content (P_{be}) expressed as a percent by weight of the total mixture. Effective asphalt content is the total asphalt used in the mixture less the percentage of absorbed asphalt.

Dust to Asphalt Ratio, D/P or P_{200}/P_{be}:

$$\text{Dust Ratio} = \frac{P_{200}}{P_{be}}$$

The dust ratio, P_{200}/P_{be}, tolerance for all Superpave mixtures is 0.6 to 1.6.

8 – Moisture Sensitivity Analysis – Lottman Test (Tensile Strength Ratio)

To complete the design process, the QC technician shall perform the moisture sensitivity test (Lottman – AASHTO T 283) to evaluate the proposed hot-mix asphalt blend for stripping. This test is not a performance-based test, but serves two purposes. First, it identifies whether a combination of asphalt binder and aggregate is moisture susceptible. Second, it measures the effectiveness of anti-stripping additives.

Subsection 502.03(b) requires that mixtures yield a minimum TSR of 75 percent for mixes containing conventional asphalt cement (PG 64-22 or PG 58-28) or a TSR of 80 percent for mixes using modified asphalt cement (PG 70-22m or PG 76-22m). In addition, the *Standard Specifications* require that the proposed JMF stipulate a single anti-strip rate, which is 0.1 percent greater than the percentage that will yield these TSR values up to a maximum of 1.2 percent. Appendix V depicts typical Lottman results and the form on which they should be reported.

Once the JMF proposal has been approved by the certified inspector, according to Subsection 502.03.b, the DOTD will also evaluate the mixture for moisture sensitivity according to AASHTO T 283. This Lottman verification will be conducted in the plant laboratory during the first lot of production. Results will be reported on the TSR Form (Appendix V) and forwarded to the district laboratory engineer with the JMF proposal.

9 – Permeability Testing

The QC technician shall perform permeability testing and report the results on the JMF Release Form. Permeability tests shall be performed on 6-inch diameter by 4-inch tall (150 mm x 100 mm) specimens, compacted to 93% ±1% of the theoretical maximum specific gravity (G_{mm}). The maximum coefficient of permeability shall be 3.5 feet per day (125×10^{-5} cm/second) as measured in accordance with ASTM PS 129-01. These same specimens may be used for moisture sensitivity testing.

10 – Submittal Process and Documentation – (JMF Release Form)

Once the optimum asphalt cement content has been determined for the proposed aggregate blend and the consensus aggregate tests, dust proportion and the moisture sensitivity analysis (Lottman test) have been completed, the certified QC technician is prepared to submit the proposed job mix formula (JMF) to the district laboratory engineer. The JMF shall be submitted on a properly completed Asphaltic Concrete Job Mix Release Form (Appendix AK) or an approved computer generated form similar to the one furnished by the DOTD (Appendix AL).

The QC technician shall submit the following information to the district laboratory engineer with the JMF.

1. A proposed blend summary with individual source and composite gradations, volumetric analysis at optimum asphalt cement content, including two N_{design} and one N_{max} briquette. (Appendix AM).

2. Bulk specific gravity, G_{sb}, of each aggregate and the combined bulk specific gravity for the mineral aggregate blend. Friction ratings if applicable. Effective specific gravity (G_{se}) of RAP and % AC.

3. A graph showing proposed composite gradation plotted to the 0.45 power with the applicable restricted zone and control points (Appendix AN).

4. A quantitative summary of three (minimum) trial blends at optimum and ± 0.5 percent asphalt cement along with volumetric calculations (Appendix AO).

5. Optimum Asphalt Cement Content Summary of Test Properties (Appendix AP) showing VMA, V_a, VFA, percent G_{mm} at $N_{initial}$ and percent G_{mm} at N_{design} versus asphalt cement content.

6. Coarse aggregate angularity (CAA) test results for material retained on the No. 4 sieve (Appendix AQ).

7. Fine aggregate angularity (FAA) test results for individual fine aggregate sources with less than 10% passing the No. 4 sieve and composite blend, if applicable (Appendix AR).

8. Flat and Elongated Count (FE) test results for coarse aggregate material retained on the No. 4 sieve (Appendix AS).

9. Sand equivalency (SE) test results for fine aggregate material (natural sands only) passing the No. 4 sieve (Appendix AT).

10. Gyratory compactor test results for two samples (laboratory or plant produced) prepared at optimum asphalt cement content for the proposed trial blend compacted to N_{design} and one sample compacted to N_{max} (Appendix AU).

11. Lottman results (from the laboratory or plant design) (Appendix V).

12. Permeability results determined in accordance with ASTM PS 129.

The original and signed JMF Release, along with the twelve supporting documents, shall be submitted together to the district laboratory engineer for approval no less than 7 days before estimated production is to begin.

The district laboratory engineer must approve the proposed mix design before any mixture can be produced for the department. Upon approval of the proposed JMF, the district laboratory engineer will give it a numerical identification (the JMF Sequence Number). This identifying code must be clearly written, typed, or printed on the JMF Release From and all supporting documentation.

11 – Approval of JMF Proposal

Upon approval of the JMF, the district laboratory engineer will sign the original in the Proposal Approved section at the bottom of the document and date it. The district laboratory will retain a copy; the original will be returned to the plant pending verification.

12 – Validation of JMF Release Submittal

Once the district laboratory engineer has approved the JMF for validation the plant may begin producing mixtures for the department in accordance with the JMF. However, before the validation process begins for the approved JMF, the project engineer in charge of the project must verify that the mix type and project specifications for the project(s) receiving the mix are the same as the proposed mix design.

It is the responsibility of the QC technician to always provide the project engineer with a copy of the JMF prior to production for a particular project. (A facsimile copy will suffice.)

JMF validation will be completed on the first production lot. The evaluation is designed to ensure that the mixture produced in the plant meets the tolerances set forth in the JMF Proposal.

The QC technician and DOTD inspector will perform JMF validation jointly on the first day's production or a maximum of 1000 tons. The QC technician and DOTD inspector shall, using the stratified random number sampling approach, take five samples, one per 200 tons during the first day's production or a maximum of 1000 tons of mixture produced.

Minimum testing, per 200 tons, shall include:

- 1 – theoretical maximum specific gravity (G_{mm})
- 1 – gyratory specimen compacted to N_{design}
- 1 – gyratory specimen compacted to N_{max}
- 1 – oven extraction.

The results from these tests shall be analyzed for the following parameters:

- Theoretical maximum specific gravity (G_{mm})
- Extracted gradation
- Percent extracted asphalt cement (P_b)
- Percent crushed aggregate (from cold feed blends)

The following parameters apply to samples aged for one hour in the oven at gyratory compaction temperature and **compacted to N_{design}**.

- Bulk specific gravity (G_{mb}) at N_{design}
- Percent G_{mm} at $N_{initial}$
- Percent V_a, VMA and VFA

The following parameters shall apply to samples aged for one hour in an oven at gyratory compaction temperature and **compacted to N_{max}**.

- Bulk specific gravity (G_{mb}) at N_{max} measured and estimated
- Percent G_{mm} at N_{max} and corrected % G_{mm} @ N_{design}
- Slope of the Gyratory Compaction Curve.

The mean and standard deviations of the test results will be calculated. The test data will be used to validate the JMF as described in the DOTD Superpave Quality Level Analysis document (Appendix AJ).

A JMF is considered validated if the following parameters are 90 percent within limits (PWL) of the JMF and the specifications limits and all other parameters are within specification limits:

- Extracted gradation for the No. 8 and No. 200 sieves
- Theoretical maximum specific gravity (G_{mm})
- Percent G_{mm} at $N_{initial}$ and N_{max}
- Percent Air Voids (V_a) at N_{design}
- Percent VMA at N_{design}

The specified tolerance used to determine upper and lower limits for PWL calculations shall be ± 0.015 for maximum theoretical specific gravity, G_{mm}, and ± 0.022 for bulk specific gravity, G_{mb}. A copy of a PWL analysis for validation considering Nos. 8 and 200 sieves, V_a, VMA, G_{mm}, and percent G_{mm} at $N_{initial}$ and N_{max} is shown in Appendix AV.

Should the JMF validate on all but one parameter, the certified QC technician may make production adjustments and repeat the validation testing using the next day's production or a maximum of 1000 tons. Should the JMF fail to validate on more than one parameter, the JMF will be considered not valid. The certified QC technician shall submit a new JMF for approval. A previously approved JMF may be used to produce HMA in lieu of the disapproved JMF.

Upon validation of the JMF, the validation parameters shall be used for acceptance. Payment for validation lots shall be in accordance with acceptance pay parameters.

The performance of the mixture on the roadway will also be evaluated to ensure that the JMF is not contributing to laydown deficiencies, such as segregation, tenderness, workability, compactability or surface texture problems. Mixtures that are identified as causing any laydown deficiency will not be validated. The project engineer in charge of the project or the district laboratory engineer may deem a proposed JMF invalid for roadway deficiencies.

Additionally, if the mixture exhibits uncoated aggregate or possible moisture problems, the QC technician and department inspector will perform **AASHTO T198 (Ross Count) to ensure that the mixture meets the 95 percent coating requirement of the specifications (Subsection 503.02(m)) or TR 319 to ensure that the moisture content of the mixture does not exceed the 0.5 percent specification requirement.**

If a mixture design fails to validate, a new proposal must be submitted and validation testing repeated or the producer may use a previously approved mix design. No mixture shall be produced for a DOTD project until the district laboratory engineer has approved a new JMF Release proposal.

If the JMF does not validate, the district laboratory engineer will indicate disapproved on the proposed JMF Release, enter the sequence number, date and sign it (Disapproved). Copies of the disapproved JMF Release will be distributed to each project engineer who received a portion of the lot.

After validating the JMF for mixture properties, the QC technician**,** witnessed by the DOTD inspector, shall sample the next day's production and perform validation testing at the plant for AASHTO T 283 (moisture sensitivity testing – Lottman) using one freeze-thaw cycle. When the validation results are less than 80 percent (or 75 percent when using PG 64-22 or PG 58-28), no further production for that JMF or any proposed JMF substituted for that mixture type will be accepted on any DOTD project having AASHTO T 283 requirements until a passing plant-produced Tensile Strength Ratio (TSR) value is verified by the department. A previously validated and approved JMF may be used to produce HMA in lieu of the disapproved JMF.

Once completed, the validation data is promptly forwarded to the district laboratory engineer. If available, this data shall then be entered into DOTD supplied software (i.e., *Q-Pave*).

13 – Final Approval of JMF

The district laboratory engineer, upon receipt of the validated JMF and supporting PWL (Percent Within Limits) calculations, will sign and date the document for a second time on the Approved Line. Copies of the approved mixture design will then be returned to the plant laboratory. Once a completed mixture design has been approved and validated, the same JMF may be used for all projects having the same specification requirements.

It is the responsibility of the QC technician to provide the project engineer (in charge of a project anticipating receiving mix from the plant) with a copy of the Job Mix Formula (cover sheet only) prior to production (a facsimile will suffice).

The district laboratory engineer will provide the contractor, producer, department plant personnel, and the project engineer who is receiving the mixture with an approved copy of the mixture design for project records.

QC Technician – Responsibilities

The primary responsibilities of the QC technician are to design hot-mix asphalt mixtures and control their production to ensure that they consistently meet departmental requirements.

The certified QC technician shall be at the plant for the beginning of daily operations. Whenever HMA mixtures are being produced for a DOTD project, the certified technician must be either at the plant or the paving site.

It is the certified technician's responsibility to perform all tasks necessary to begin plant operations. This includes, but is not limited to, checking asphalt cement working tanks, material stockpiles, aggregate bins, cold feed settings, meters and scales. The certified technician is responsible for recommending appropriate adjustments and ensuring that these adjustments have been made during continuing operations to ensure uniformity and conformance to specifications.

In addition, the certified technician shall oversee and monitor the complete production, transport, placement, and compaction phases to ensure compliance with DOTD standards and to promote consistency. It is imperative that the technician use experience and common sense to analyze problem situations.

The certified technician shall be cognizant of proper plant operations and be aware of moisture inconsistencies. When the plant is put into operation, the technician shall monitor stockpiles to ensure that they are constructed properly and that moisture contents entered into the plant controls are consistent with actual values for each material bin.

Plant operations are to be continuously inspected to ensure the following:

- Proper bag house operation (Startup and shutdown loads will be impacted by improper sequence of fines return from the dust collection system, producing material with inconsistent amounts passing the No. 200 sieve.)

- Sufficient HMA is wasted at startup and shutdown to ensure adequate, sufficient, and consistent asphalt cement rates.

- Proper loading of trucks to minimize material segregation.

Proper sampling is crucial for accurate results that represent actual plant production.

Gradation

Subsection 502.12(a) states that, for control purposes, the contractor/producer shall obtain one loose mixture sample taken from each sublot after placement of the mix in the truck and tests will be performed for extracted gradation (AASHTO T 30), percent crushed (TR 306), and asphalt cement content (TR 323) for each sublot (1000 tons). The lot average and standard deviation shall be determined for aggregate gradation and asphalt cement content. The Percent Within Limits (PWL) shall be determined on the No. 8 and No. 200 sieves and for G_{mm}. All gradations on intermediate sieves shall be reported. Corrective action and test results shall be reported in an approved format to the DOTD plant inspector.

This specified QC Program is only a minimum requirement and should not prevent the technician from performing any test(s) in any frequency to ensure consistency, within specification limits. The full range of gradation mix tolerances will be allowed even if they fall outside the control points.

The technician should also, at regular intervals, check to ensure that the aggregate proportioning system is in calibration. This may be a two-step process. First, the weighbridge is checked, after plant production has ceased, to ensure that it is in calibration. This may be determined by running a known mass of material over it and correcting the weighbridge factor to get it into calibration over the full span of expected weights. Secondly, each feeder bin may be stopped, during normal operations, for 10 to 15 seconds, once the weighbridge has stabilized, to determine if the proper mass of material/per unit time is being proportioned from the individual bin. This type of quick check is typically referred to as checking the calibration on the fly. However, this type of check is **only accurate if it is known that the master weighbridge is in correct calibration.**

There are other methods for checking cold feed calibrations, such as that in DOTD's publication, *Cold Feed Adjustments for Asphaltic Concrete Plants*. In any method used, the measured weight of the aggregate includes moisture in the aggregate. Moisture content (M.C.) for each aggregate is calculated by the following equation:

$$\text{M.C.\%} = \frac{(\text{Wet Weight} - \text{Dry Weight})}{\text{Dry Weight}} \times 100$$

Therefore, to determine the *dry* mass, knowing moisture content, the following equation may be used:

$$\text{Total Dry Weight} = \frac{\text{Total Wet Weight} \times 100}{100 + \text{M.C.\%}}$$

All cold feed bins shall be provided with indicators to show the gate opening in inches. Further, each bin opening shall be rectangular, with one dimension adjustable by positive mechanized adjustment with a locking system.

Should the extracted gradation begin to vary erratically, the aggregate proportion system should be immediately checked along with individual stockpile gradations.

Asphalt Cement Content

The asphalt cement content may be determined two ways. The ignition oven (TR 323) may be used along with a correction factor. Also, the rate of asphalt cement delivery is continuously shown, in digital form, on all modern plant controls. If these two values differ significantly, then the correction factor for the ignition oven needs to be re-evaluated or the plant asphalt cement metering system needs to be recalibrated. The latter is done by metering a quantity of asphalt cement into a tanker or tank that can be readily weighed on a set of calibrated scales or load cells. Note that excess moisture in the mix may falsely appear as asphalt cement during the Ignition Oven test procedure; it may also artificially lower the G_{mm} and artificially increase the G_{mm}. Higher asphalt content will also reduce G_{mm}.

Laboratory Volumetrics

The QC technician shall conduct quality control tests to ensure that volumetrics are within specification range. The two (minimum) samples of mixture taken from each sublot shall be evaluated for G_{mm}, G_{mb} estimated @ N_{max}, and %G_{mm} @ $N_{initial}$ estimated. These values shall be reported in an approved format to the DOTD plant inspector (Appendix AW).

Additives

The QC technician shall check the rate of anti-strip at the beginning of each operational period, and when necessary thereafter, to ensure that the mixture is receiving the JMF percent of anti-strip.

If mineral filler or lime is used, the QC technician shall also check the mineral filler or lime at the beginning of each operational period, and when necessary thereafter, to ensure that the mixture is receiving the JMF percent of additive.

Temperature

The temperature of the asphalt cement and of hot-mix asphalt is very critical. It is also critical that the temperature of these two products be as specified and be consistent.

Specific attention shall be given to monitoring temperature in all asphalt cement working tanks and to ensure that all materials added, particularly from transports, are also at the correct elevated temperatures. Temperature is directly correlated with viscosity, which will affect the material's ability to adequately coat the aggregate.
Specifications require that a thermometer be provided to indicate mixture discharge temperature (typically at the discharge of the drum mixer). Mixture temperature consistency is essential in obtaining consistent roadway compaction. The technician may check this thermocouple temperature against either an infrared gun-type thermometer device or by using a standard, calibrated dial thermometer.

The JMF stipulates an optimum mixing temperature range of ±25° F of the optimum mixing temperature for the asphalt cement used (as supplied by the refinery). The discharge temperature shall always be within this range. . **Mixing temperature must never exceed 350° F at the point of discharge, regardless of the supplier's recommendations.** Further, Subsection 502.07 of the *Standard Specifications* states that no mixtures shall be delivered to the paver cooler than 25° F below the lower limit of the compaction temperature as shown on the JMF. (The temperature of the mix going through the paver shall not be cooler than 250° F.) The technician shall randomly select five portions of the lot for temperature checks.

Moisture

Stripping of asphalt courses will not occur in the absence of moisture or moisture vapor. To approach this ideal state, all hot-mix asphalt materials should be produced in a manner that minimizes internal moisture, because internal aggregate moisture can weaken the molecular bond between the asphalt cement (binder) and the mineral aggregate.

However, with the average annual rainfall and humidity present in Louisiana, it is difficult to remove all free and absorbed moisture from aggregate in the HMA production process. In a typical plant when fuel is burned, a quantity of heat is produced. This heat is transferred to the aggregate to evaporate moisture and heat the aggregate. As moisture in the aggregate is evaporated, each pound of water expands to 33 cubic feet of steam. This enormous volume of steam must be removed by the plant's exhaust system. Hence, when aggregate moisture values increase (as in the presence of recent rainfall), the plant's production rate and burner settings must be adjusted to maintain and achieve consistent mixture temperatures and remove sufficient moisture. The drum mixer shall also be routinely inspected for excessive flight wear. Excessively worn or missing flights will greatly affect the plant's ability to heat and dry aggregates.

The presence of moisture also aggravates the process of accurately measuring mixture volumetrics. Excessive moisture in hot-mix asphalt may lead to an abrupt collapse in voids in mineral aggregate.

The certified technician, as part the Quality Control Plan, shall continually monitor the moisture in the individual aggregate stockpiles (TR 403) and of the loose hot-mix asphalt (TR 319).

Documentation

The QC technician shall keep, as a minimum, the following records on file at the plant laboratory:

1. A Superpave Asphaltic Concrete Plant Report form (Appendix AW) for each lot showing a minimum of one extracted asphalt content, gradations for all sieves and percent crushed values for each sublot. These gradations, asphalt cement content and percent crushed test results shall be entered on the QC copy of the Plant Report form. Corrective action shall be taken if PWL for No. 8 sieve, No. 200 sieve, or G_{mm} falls below 90.

2. The Plant Report form shall also show a minimum of two results per sublot (on unaged samples) with appropriate control charts for the following:

    - Theoretical Specific Gravity (G_{mm})
    - Estimated Bulk Gravity (G_{mb}) at N_{max}
    - Percent G_{mm} at $N_{initial}$

3. Percent Moisture in loose mix once per lot (Appendix AI).

4. Asphaltic Concrete Control Charts (Appendix AC).

If the control charts show that the mixture being produced is not uniform, the QC technician shall correct operations and produce a uniform mixture or discontinue operation for DOTD. When the average of five extracted gradation tests per lot (one per sublot) on any sieve fall outside of the allowed tolerance of the approved JMF limit, the QC technician shall immediately make corrections to keep the mixture within specified limits. Failure to keep the mixture within specified limits shall result in the contractor's being prohibited from supplying this mixture to DOTD projects.

The QC technician shall document all corrections to control the mixture and prevent any aspect of the mixture from moving outside specified limits or from varying erratically within those limits on the back of the control chart. This documentation shall include the action taken, date and time and be initialed by the QC technician. If the test results for any control chart cannot be plotted in the space provided on the control chart, the technician shall document the corrective action taken on the back of the chart. **The control charts shall be maintained per plant lot per job mix.**

The QC technician is to document all QC testing and keep these records on file at the plant laboratory. The certified technician shall stamp all QC documents "QC" with red ink, in minimum one-inch high letters.

DOTD Certified Inspector - Responsibilities

The DOTD certified inspector is the department's official representative at the plant. The DOTD certified inspector is responsible for the following:

1. Ensuring that the QC technician performs all tasks required
2. Checking the QC program (of the contractor/producer) to ensure that it is in conformance with department requirements
3. Ensuring that, through inspection, the HMA product meets all department standards.

The DOTD inspector is also responsible for ensuring that material samples required for department testing are obtained in accordance with prescribed testing schedules and frequencies, that all samples are representative of the material and that the samples are submitted, along with appropriate forms and documentation, to the appropriate testing facility in a timely manner. Additionally, the DOTD certified inspector is responsible for performing all acceptance sampling and performing all acceptance tests on the product as delineated in this manual. During validation, the DOTD inspector and QC technician may work together to perform sampling and testing to minimize tester variation. However, during production, the DOTD inspector must take and test acceptance samples.

Subsection 502.12(b)(2) of the *Standard Specifications* outlines the required acceptance tests to be performed by the DOTD inspector. These tests are performed at the plant unless directed otherwise by the laboratory engineer. Sampling must follow a stratified sampling plan in accordance with the *Materials Sampling Manual* and specified test procedures. Random number tables were developed to ensure that sampling would occur at different times during production, and therefore, be representative of the mix. Since an inspector cannot always stop a test procedure to obtain a sample, some flexibility is allowed. The acceptance tests are listed below:

- Percent Anti-Strip – Payment Factor Applied
- Air Voids, V_a (at N_{design}) – Payment Factor Applied
- Voids in Mineral Aggregate, VMA (at N_{design}) – Payment Factor Applied
- Pavement Density – Payment Factor Applied
- Surface Tolerance – Payment Factor Applied
- Asphalt Cement Properties - Payment Applied Separately

Testing for surface tolerance (profilograph) will be required for each lot on the final roadway wearing course and airport wearing course lift. The DOTD Certified Paving Inspector and the Contractor's Authorized Profilograph Operator and Evaluator will be responsible for the determination of these surface smoothness values.

Asphalt Cement Properties – Payment Factor Applied

The DOTD inspector will sample shipments of asphalt cement and submit them for testing to the district laboratory in accordance with the requirements of Section 508 of the *Materials Sampling Manual*.

Samples shall be clearly marked with the following:

- Plant MATT Code, e.g., H312
- Asphalt Cement Type
- JMF Sequence Number
- Lot Number

Appendix AF and AG show copies of the required asphalt cement and performance graded asphalt cement submittal forms that shall accompany each sample of asphalt cement when submitted to the district laboratory.

The district laboratory will test one sample for Dynamic Shear (TP 5). Should this sample fail TP 5, the district laboratory will promptly notify the project engineer and the QC technician. The contractor shall notify the refinery.

Asphalt cement in the plant's working tank must meet the specifications of the asphalt cement required on the JMF.

The DOTD inspector will document the metered asphalt cement content on the Superpave Plant Report. It should be noted that if the ac content from the meter or scales does not fall within ±0.1% of the optimum ac on the JMF, the DOTD inspector will take a second determination immediately. If these results indicate continued lack of conformance to %AC requirements, the contractor/producer shall discontinue operations for DOTD until the process has been corrected to the satisfaction of the district laboratory engineer.

Temperature

The DOTD inspector shall check the mix temperature in the truck five times per lot and record it on the Asphaltic Concrete Plant report form (Appendix AW) along with the accumulated lot tonnage corresponding to the time when the temperature was noted and recorded.

Percent Anti-Strip – Payment Factor Applied

An anti-strip additive shall be added to all mixtures at no less than the minimum rate determined in accordance with AASHTO T 283, at a rate not below 0.6 percent nor above 1.2 by weight of asphalt, in accordance with Subsection 502.03(b).

The DOTD inspector will test for the amount of anti-strip at a frequency of twice per lot. The lot will be divided into two approximately equal sublots. If the percentage of anti-strip added to the mixture is not in accordance with the minimum required on the JMF, a payment adjustment factor will be applied to the lot in accordance with Table 502-7 – Payment Adjustments Schedules for Superpave. If the check performed indicates that the amount of anti-strip added is not in accordance with the JMF, the contractor must make adjustments so that the correct amount of anti-strip additive will be added to the mixture. If the second check indicates that the mixture is still not receiving the correct percentage of anti-strip, production for DOTD projects shall be terminated until adequate adjustments can be made to the system or the system can be recalibrated.

An example of applying payment adjustment factors for deficient anti-strip is as follows:

> Assume that the minimum percent anti-strip (%AS) that will yield 80 percent TSR, as determined by T 283, is 0.5 percent. Accordingly, the JMF then establishes 0.6% as the percentage of anti-strip to be incorporated in the mixture. Therefore, the contractor is allowed to operate between 0.5% to 0.7% anti-strip.
>
> Upon inspection, the DOTD's technician checks the AS meter and determines that the mixture produced since the last check (2573 tons) has received only 0.3%.
>
> The 2573 tons produced at this percent anti-strip will cause an adjustment of the contract unit price for the lot, in accordance with Table 502-7. The computation of this penalty will be as follows:
>
> *The test, which represented one-half of the lot, indicated that the half-lot received only 0.3% AS, which results in 95 percent pay for that half-lot. The test for the second half lot indicated that the mix received 0.6% AS, which results in 100 % payment for the second half lot. Therefore, to calculate the payment adjustment for this lot:*

$$\text{Payment Adjustment} = \left(\frac{\%\ \text{payment for } 1^{st} \text{ half of lot} + \%\ \text{payment for } 2^{nd} \text{ of lot}}{2} \right)$$

$$\text{Payment Adjustment} = \left(\frac{95 + 100}{2} \right)$$

$$\text{Payment Adjustment} = 97.5 \text{ or } 98 \text{ percent}$$

The results of the percent anti-strip are entered on the Superpave Asphaltic Concrete Plant Report Form (Appendix AW). These reading are to coincide as closely as possible to approximately each half of a plant lot.

The basic method of checking the percentage of anti-strip in the mixture is to monitor the flow of additive for a continuous time sufficient to represent approximately half a lot. In order to proceed with the calculations for the percentage of anti-strip, the technician must know the unit weight of the anti-strip additive at any given temperature. The anti-strip supplier must make the unit weight information available or a one-gallon sample may be weighed at the plant to determine this value.

An example of determining percentage of anti-strip added to HMA follows:

1. Read and record the temperature of the anti-strip additive being added to the mixture from the thermometer on the anti-strip tank.

2. Take an initial reading of the amount of anti-strip additive from the anti-strip meter. Record the reading to the nearest readable increment (0.1 gallon or 0.25 gallon). Allow the plant to run for a continuous period of time sufficient to represent approximately half a lot. Take a final reading to the nearest readable increment and record.

3. Subtract the initial reading from the final reading to obtain the actual amount of anti-strip used during the time period.

4. Take an initial reading from the asphalt cement totalizing meter and record to the nearest gallon. (Some plants will digitally display the mass of asphalt cement added on the computerized operational controls.) Allow the plant to run for the same period of time as used for AS determination. Take a final reading of AC used and record to the nearest gallon. Subtract the initial reading from the final reading to obtain gallons AC used. **It is required that the percent asphalt cement and the percent anti-strip be checked simultaneously during continuous production to evaluate the quality of the mixture in terms of both components.**

Calculate the percent anti-strip in terms of the weight of asphalt cement in pounds.

$$\% \text{ AS} = \left(\frac{\text{pounds of anti} - \text{strip}}{\text{pounds of asphalt cement}} \right) x100$$

Calculate pounds of anti-strip:

Unit weight of anti-strip	= 7.28 lb/gal (from curve)
Gallons anti-strip used during check	= 41.25 gal

7.28 lb/gal x 41.45 gal = 301.8 lb

Calculate pounds of asphalt cement:

Gallons AC used during check	= 5820 gal
Weight of 1 gallon of water	= 8.34 lb/gal
Specific Gravity of AC @ 60°F	= 1.03

5820 gal x 8.34 lb/gal x 1.03 = 49,994.964 lb

Calculate the percent anti-strip:

$$\% \text{ AS} = \left(\frac{301.8}{49{,}994.964} \right) x100$$

= 0.603

= 0.6 % anti-strip

Report the final percentage of anti-strip additive to the nearest 0.1 percent.

If lime or another other additive is being proportioned in the HMA mixture at the plant (and shown on the JMF) then this rate shall also be determined twice per lot, via the plants meters/scales, and shown on the QC copy of the Superpave Asphaltic Concrete Plant Report form (Appendix AW).

Laboratory Volumetrics – Payment Factors Applied

The department's inspector will test for volumetrics (V_a and VMA) at a rate of one test per sublot from samples taken randomly after the mixture is placed in trucks. One sample will be taken from each of the five sublots. The temperature of the mixture in the truck, at the time of sampling, shall also be recorded on the Asphaltic Concrete Plant Report form (Appendix AW).

The DOTD inspector will prepare the samples (gyratory briquettes) in accordance with AASHTO TP 4, PP 19 and T 166. The plant produced mixes will be cured one hour (at compaction temperature) in the mold prior to compaction. Aggregates with water absorption greater than 2% will require a 2-hour aging period as compared to those with low water absorption values.

After aging, the mix will be gyrated to N_{design} gyrations per Table 502-4 for the specified level and type of mix. The cooled briquettes will be tested for specific gravity (G_{mb}) and compared to the theoretical maximum gravity (G_{mm}). G_{mm} and G_{mb} are determined for each sublot and performed by the DOTD inspector for acceptance. V_a and VMA will then be calculated. These test results will be reported on the approved Superpave plant worksheets and/or QPave or approved computer spreadsheet.

The test results for volumetrics (V_a and VMF) shall be in accordance with the JMF and Table 502-6. Payment Adjustment Schedules. If test results indicate that payment adjustments are necessary, satisfactory adjustments shall be made or production shall be discontinued.

An example of determining percent payment for V_a and VMA, using the *DOTD Superpave Quality Level Analysis* document (Appendix AJ), follows:

Lot 105 – 5010 tons of Superpave Level (19.0 mm NMS)

V_a and VMA results for Lot 015:

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
V_a	4.3	5.1	4.7	4.1	4.4
VMA	14.3	13.7	13.9	14.4	14.2

Listed below are the Percent Within Limits calculations required to determine the unit price payment for V_a and VMA for Lot 015:

	Mean	Std Dev	Spec Low	Spec High	Q_L	Q_U
V_a	4.5	0.39	3.0	5.0	3.85	1.28
VMA	14.1	0.29	13.0		3.77	

Note that there is no maximum specification for VMA.

Note also that the significant digits for standard deviation are always one more significant digit than the reported parameter. For example average voids is x.x, standard deviation is x.xx. The average G_{mm} is x.xxx: standard deviation is x.xxxx.

The Lower Quality Index (Q_L) is calculated by the following formula:

$$Q_L = \frac{(\text{Mean} - \text{Lower Specification Limit})}{\text{Standard Deviation}}$$

$$Q_L = \frac{(4.5 - 3.0)}{0.39} = 3.8461 = 3.85$$

The Upper Quality Index (Q_U) is calculated by the following formula:

$$Q_U = \frac{(\text{Upper Specification Limit} - \text{Mean})}{\text{Standard Deviation}}$$

$$Q_U = \frac{(\ 5.0 - 4.5\ )}{0.39} = 1.2820 = 1.28$$

Table 1 in the *DOTD Superpave Quality Level Analysis* document (Appendix AJ) is used to convert the Quality Indices into the PWL value. A PWL is calculated for each Quality Index (upper and lower) and combined for a total PWL calculated in accordance with the following formula:

$$PWL = PWL_L + PWL_u - 100$$

Where:

PWL_L = Lower Percent Within Limits
PWL_U = Upper Percent Within Limits

In using Table 1, the appropriate columns corresponding to the number of test results must be used. In most cases, five test results (corresponding to the number of sublots) for JMF validation and lot acceptance testing will be used.

So, for our example, the PWL calculations for V_a and VMA are as follows:

For $\mathbf{V_a}$,

PWL_L = 100 (from Table 1 for n = 5 and Q_L = 3.85)

PWL_U = 92 (from Table 1 for n = 5 and Q_U = 1.28)

Therefore:

$$PWL = 100 + 92 – 100 = 92$$

And for **VMA**,

PWL_L = 100 (from Table 1 for n = 5 and Q_L = 3.77)
PWL_U = 100 (if a specification requirement does not have a range [e.g., VMA has only a minimum specification limit]). Only one Quality Index and PWL, upper or lower as appropriate, is calculated and the other PWL is equal to 100 in the total PWL calculation.

Therefore:

$$PWL = 100 + 100 – 100 = 100$$

A mixture with any parameter below 40 PWL is subject to removal as directed by the project engineer.

The percent payment for each of the parameters (V_a and VMA) are then calculated using the formula:

$$\text{Percent Payment} = 55 + (0.5 \times PWL)$$

So, for $\mathbf{V_a}$,

$$\text{Percent Payment for } V_a = 55 + (0.5 \times 92) = 101.0$$

And for **VMA**,

$$\text{Percent Payment for VMA} = 55 + (0.5 \times 100) = 105.0$$

This may not be the final percent pay for a project since, for plant acceptance, the percent payments for V_a, VMA, and anti-strip are averaged to determine plant acceptance payment. The maximum percent payment for plant acceptance will be 100%.

For roadway acceptance, the PWL will be calculated for the pavement density of each sublot. The percent payment for pavement density for the lot will be the average of all sublots. The percent payment for roadway acceptance will be the average of the percent payments for pavement density and surface tolerance. The maximum percent payment for roadway acceptance will be 100%.

Finally, the percent payment for the Superpave lot will be the lowest value of the percent payments for plant acceptance and roadway acceptance.

This information shall be reported by QPave printout or on approved DOTD worksheets.

Pavement Density

Upon completion of compaction procedures, QC personnel shall obtain five pavement samples from each portion of the plant sublot per mix use placed on a specific project. DOTD's certified paving inspector will select sampling locations for pavement density cores by application of the Random Number Tables (DOTD S605) in the *Materials Sampling Manual*. If a sampling location falls within one foot of an unsupported edge or within an obviously bad spot that is to be replaced, another sampling location shall be selected through the reapplication of the Random Number Table. The inspector should make certain that the core location is in an area of pavement that is representative of the lot. Cores of pavement widening are required. The DOTD paving inspector, upon determination of the coring locations, will provide the contractor/producer coring representative with a list of the coring stations (with transverse dimension). The cores shall be taken within 5 feet of the selected location according to this list. The contractor shall fill and compact all core holes with asphaltic concrete or cold mix.

The contractor shall take core samples within 24 hours after the mix is placed, unless this deadline falls on a day that the contractor's crews are not working. In this case, the contractor shall take core samples within 3 calendar days. For patching or widening operations, this time limit may be extended until the HMA has cooled sufficiently for coring to proceed.

The project sublot portion will be divided into five sections of approximately equal length; one sample shall be obtained from each sublot. Each portion of a sublot placed on a given project (per use) will always be represented by exactly five samples for pavement density testing, with the exception of small quantities and patching and widening operations. If a sublot has two different mix uses (e.g., shoulder and travel lane), the PWL for each shall be computed and prorated by tonnage to determine a PWL for the entire sublot. For example: 1000 ton sublot

300 tons of shoulder @ 95 PWL
700 tons of roadway @ 100 PWL

$$\frac{(300 \ \text{x} \ 95) \ \text{x} \ (700 \, \text{x} \, 100)}{300 + 700} = 98.5 \, \text{PWL} = 99 \, \text{PWL}$$

Since pavement density must be compared to the theoretical maximum density (G_{mm}) for the lot, the core samples must be clearly identified by sublot and lot number. The date the samples are taken will be recorded on the Superpave Roadway Report (Appendix AX). If the sample obtained from a pavement sublot is less than 1 3/8 inches thick, the DOTD Certified Paving Inspector will reject the core and select another sampling location for that sublot by reapplication of the Random Number Tables. The core sample's official measurement will be obtained by taking three measurements spaced uniformly around the circumference of the core. These measurements will be taken to the nearest 1/8-inch. The average of these measurements will be considered the official measurement and will be recorded by the DOTD plant inspector to the nearest 0.01-inch on the Superpave Roadway Report (Appendix AX). Roadway cores shall be obtained and handled in accordance with Subsection 502.09.

HMA mixtures placed in design layers less than 1 3/8 inches thick shall be compacted by approved methods to the satisfaction of the project engineer and shall not require coring.

Should a specimen be damaged during operations, the contractor/producer coring representative may move longitudinally up or down the pavement within five feet to procure another specimen.

The DOTD inspector will evaluate the five pavement cores for bulk specific gravity (G_{mb}) (AASHTO T 166), and compared, as a percentage, to the theoretical maximum specific gravity (G_{mm},) reported for the sublot. The percent G_{mb} determined for each pavement sample will be used to calculate a PWL for the sublot. Specific attention should be given to ensure that the pavement cores are sufficiently free of moisture. This shall include placement of the cores in a force draft oven at 125° F until a constant mass is ensured in accordance with AASHTO T 166. Constant mass is defined as the mass at which further drying at 125° F does not alter the mass by more than 0.05 percent. **For permeable mixtures this error can be significant.**

The DOTD paving inspector, along with the contractor/producer coring representative, will inspect the cores for acceptability and label them for identification. The DOTD inspector and the QC technician at the plant, upon inspection and mutual agreement, also reserve the right to reject any core(s). It is intended that cores be delivered to the plant on the same day as they are taken, so that the results for acceptance and verification can be made available to the project engineer and field compaction personnel in a timely manner.

The DOTD inspector will package the core for transport and place the original and one copy of the Superpave Roadway Report (Appendix AX) and the Asphaltic Concrete Verification Report (Appendix AZ) in the packaging.

For HMA patching and widening, one sample will be taken per 200 tons (or less) up to a maximum of five samples for that portion of each sublot placed on a project. If the portion of a sublot that is delivered to a project extends beyond one day’s production, a maximum of five samples will be tested for acceptance purposes. These five samples should be apportioned so that they proportionally represent the percentage of the sublot placed on the project each day. For density, sample and test the top four inches of the finished sections.

Pavement density testing shall not be required for guardrail widening. In addition, pavement density requirements will not be applied to short irregular sections in accordance with Subsection 502.12 of the *Standard Specifications*.

Subsection 503.02 of the *Standard Specifications* requires that a plant laboratory, in order to comply with certification requirements, be equipped with a saw suitable for sawing HMA pavement cores. This saw may be used by the contractor/producer to reduce patching/widening cores to four inches, remove base course material (e.g., soil cement and/or curing membrane), or to uniformly cut 4 or 6-inch diameter cylindrical samples. Care must be taken to minimize the amount of material cut and discarded, especially from the upper surface.

An example of determining percent payment for Pavement Density for a sublot follows:

Sublot 99-A = 969 tons of Superpave Level (19.0 mm NMS)

Mix delivered to the following projects:

Project A = 506 tons
Project B = 463 tons

Density results for Sublot 99-A:

	Sublot 1	**Sublot 2**	**Sublot 3**	**Sublot 4**	**Sublot 5**
Project A	92.8	93.3	94.0	94.5	91.8
Project B	93.8	93.0	92.0	92.8	93.1

Listed below are the PWL calculations required to determine the unit price payment for pavement density for Sublot 99-A:

	Mean	**Std Dev**	**Spec Low**	**Spec High**	**Q_l**	**Q_u**
Project A	93.3	1.05	92.0		1.24	
Project B	92.9	0.65	92.0		1.39	

Note that there is no maximum specification for pavement density.

For **Project A**:

$$Q_l = \frac{93.3 - 92.0}{1.05} = 1.24$$

PWL_L = 91 (from Table 1 for n = 5 and Q_L 1.05)

Therefore:

PWL = 91 + 100 – 100 = 91

And for **Project B**:

PWL_L = 94 (from Table 1 for n = 5 and Q_L= 1.39)

Therefore:

PWL = 94 + 100 – 100 = 94

A mixture with any parameter below 40 PWL is subject to removal as directed by the Project Engineer.
The percent payment for each of the parameters (V_a and VMA) are then calculated using the formula:

$$\text{Percent Payment} = 55 + 0.5 \times \text{PWL}$$

So, for **Project A**:

$$\text{Percent Payment for Project A} = 55 + 0.5 \times 91 = 100.5$$

And for **Project B**:

$$\text{Percent Payment for Project B} = 55 + 0.5 \times 94 = 102.0$$

This shall be reported on approved DOTD worksheets, or when available on a QPave printout.

This is an example for only one sublot. This may not be the final percent pay for a lot, since other sublots must be considered.

Notes on the determination of the bulk specific gravity (G_{mb}) of a pavement core:

Weighing an object (as we do with an HMA core) to determine its mass in air and its mass in a fluid (as we do in water) whose specific gravity is known yields sufficient data to determine its weight (mass), volume, and specific gravity. Specific gravity is defined as the ratio of the weight of a unit volume of the sample to the weight of an equal volume of water at approximately 25° ±1° C, (77 ±1.8° F).

LA DOTD now specifies that the G_{mb} be determined by TR 304 (AASHTO T166). The equation from the test method, for calculating G_{mb} is as follows:

$$G_{mb} = \frac{\text{Weight in Air}}{(\text{SSD Weight} - \text{Weight in Water})}$$

As the size of the external voids in the specimen increase, it becomes difficult to determine an accurate SSD mass, because the diameter of the voids are of such size that the water will run out of them before an accurate SSD mass can be determined.

Additionally, an absorptive aggregate (whose cross-sectional area is exposed on a cored pavement specimen) will absorb additional water, which in turn will produce an artificially high G_{mb}.

To account for this, AASHTO T 166 provides for an alternate test procedure (AASHTO T 275 – Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin) for determining G_{mb} when the percent water absorbed by the specimen exceeds 2.0 percent as determined by the following equation:

$$\text{Percent } H_2O \text{ Absorbed (by Volume)} = \frac{(\text{SSD Weight} - \text{Weight in Air})}{(\text{SSD Weight} - \text{Weight in Water})}$$

In addition to AASHTO T 166 and T 275, there exist two other methods to determine G_{mb} of a cored pavement specimen. One method, the Pure Volume method, is performed by measuring the thickness and diameter of the cylindrical specimen in numerous locations to calculate average values and then using the following formula to determine its volume:

$$\text{Volume} = \pi \text{ x } \left(\frac{\text{Diameter}}{2}\right)^2 \text{ x Height}$$

This volume is used in the denominator with dry weight in air in the numerator to determine the G_{mb}.

The second method, which uses proprietary equipment, involves weighing the submerged specimen in a vacuumed plastic bag to determine a true volume.

In summary, if the QC technician or the DOTD inspector suspects that G_{mb} values determined via TR 304 (AASHTO T 166) in the field laboratory are yielding erroneous values, the district laboratory engineer is to be notified.

NOTE

AASHTO T 275 and the pure volume method are not approved DOTD test methods. Results obtained from these procedures are informational only.

Surface Tolerance Requirements

The contractor/producer shall provide an approved 25-foot California-Type Ames Profilograph calibrated and operated in accordance with DOTD TR 641 for longitudinal surface tolerance quality control and quality acceptance testing. (The contractor may elect to use alternate or automated profilographs in lieu of the standard specified profilograph for Quality Control with the approval of the Materials Engineer Administrator.)

Quality control test results have the same requirements as acceptance test results. The quality control trace may be used for project acceptance, providing the DOTD inspector accompanies the profilograph operator and takes immediate possession of the trace upon completion of the quality control evaluation. Acceptance testing is required in both wheel paths.

For transverse and longitudinal surface tolerance acceptance testing, the contractor shall also furnish a minimum 10-foot metal static straightedge.

The operation of the profilograph, including evaluation of the profile trace, determination of the Profile Index, calculation of the Average Profile Index and the determination of high points (bumps) in excess of specification limits shall be performed by a trained, authorized technician who has successfully completed the department's training and evaluation program for Profilograph Operator and/or Profilograph Evaluator.

Surface tolerance testing will be required on roadway travel lanes and airport wearing (one pass on either side of the runway centerline) and binder courses, and shoulder and parking area wearing courses. For the purposes of surface tolerance requirements, the wearing course is defined as the last lift placed. The binder course is defined as the last lift placed prior to the wearing course.

Other lifts on which additional HMA is to be placed shall be finished so that succeeding courses will meet the specification requirements.
The finished surface will be tested in the longitudinal direction for conformance to the surface tolerance requirements (listed in Table 502-7). When testing roadway travel lanes and airport wearing and binder courses using the profilograph, both wheel paths in each paving strip in a lot will be selected for quality control and acceptance testing. The test path selected will be the inside wheel path of each paving strip adjacent to the centerline.

The contractor shall test the pavement during the first workday following placement, but in no case any later than 14 calendar days. (Profilograph operations should be scheduled to reduce traffic congestion around an on-going paving operation.)

When QC testing establishes that the surface tolerance is deficient, the contractor shall immediately suspend paving operations. Paving operations will not be allowed to resume until appropriate corrections have been made and a test section successfully placed with acceptable surface tolerance. This test section shall consist of a maximum of 500 tons of HMA placed in a continuous operation.

The contractor shall correct deficiencies determined during quality control testing. These deficiencies shall be corrected in the final wearing course by diamond grinding and applying a light tack coat, or removing and replacing, or furnishing and placing a supplemental layer of wearing course mixture at least 1 ½ inches of compacted thickness for the full width of the roadway at no direct pay. Deficiencies to be corrected in binder courses shall be corrected by diamond grinding or other suitable means to meet specification requirements.

After the contractor has completed QC testing and any required corrective work, the department will evaluate the profile trace from the contractor's quality control tests. Longitudinal variations in the final wearing course surface will be subject to provisions in Table 502-7 Payment Adjustment Schedules. The contractor will be allowed to evaluate the final quality control trace to determine if any corrective measures are needed to eliminate deficient areas. Upon completion of the contractor's evaluation, the DOTD inspector will take possession of the final quality control trace to be used for project acceptance. To correct deficiencies, it will be necessary to reprofile affected areas and recompute the profilograph index using the original trace and the reroll traces. DOTD reserves the right to perform independent acceptance testing.

The surface of each shoulder will be tested longitudinally by the engineer at a minimum of one randomly selected location of each 300 linear feet of shoulder using the 10-fool metal static straightedge. Areas with surface deviations in excess of ½ inch will be isolated by the engineer and shall be corrected by the contractor. **Surface tolerance requirements will not be applied to short irregular sections in accordance with Subsection 502.12 of the *Standard Specifications*.**

Excessive rippling of the mat surface will not be accepted. Ripples are small bumps in the pavement surface, which usually appear in groups in a frequent and regular manner. Specifically, a ripple is visible on the profile trace, but does not appear above or below the 0.2-inch (5 mm) blanking band required by DOTD TR 641. There shall be no more than 12 ripples or peaks in any 100-foot (30-m) section. Rippling indicates a problem with the paving operation or the mix that requires immediate correction by the contractor. Otherwise, the contractor shall cease operations. The contractor shall correct unacceptable areas at no direct pay.

Transverse Surface Tolerance - The transverse surface finish shall be controlled so that the values shown in Table 502-3 will not be exceeded.

Cross Slope Tolerance - When the plans require the section to be constructed to a specified cross slope, tests shall be run at selected locations using a stringline, slope board or other comparable methods. The cross slope shall be so controlled that the values shown in Table 502-3 will not be exceeded. Cross slope variation allowed in Table 502-3 shall be apply to each lane constructed.

Grade Tolerance - When the plans require the pavement to be constructed on a grade, tests for conformance shall be run at selected locations using a stringline or other comparable method. Grade variations shall be controlled so that the tolerance shown in Table 502-3 will not be exceeded. Grade tolerances shall apply to only one longitudinal line, such as the centerline or outside edge of pavement.

Surface Tolerance Variation	Transverse	Cross-Slope	Grade
Roadway Travel Lane Wearing Courses	1/8 inch	3/8 inch	½ inch
Binder Course	¼ inch	½ inch	½ inch
Shoulder Wearing Course	3/16 inch	¾ inch	¾ inch

Transverse and Cross Slope are based on 10 feet.
Grade is applicable only when specified.

The project engineer will review the profile trace obtained for each binder and wearing course on a per lot basis. In special cases or extenuating circumstances, the engineer may isolate sections of the profile trace that are out of specification. These sections may be excluded from the calculations of the Average Profile Index. These special cases may include curb and gutter sections which require the adjustment of cross-slope in order to maintain adequate drainage, manholes, catch basins, valve and junction boxes, street intersections or other structures located in the roadway that will cause abrupt deviations in the profile trace. High points in excess of 0.3 inch in 25 feet shall be corrected unless, in the opinion of the project engineer, these high points do not cause damage to the roadway section or rideability. These high points then may be allowed to remain with a $500.00 per bump rebate. In all cases, the contractor has the option to grind the bumps to meet the specifications. The exclusion comments mentioned in this paragraph do not apply to multi-lift new construction and overlays with more than two lifts.

Dimensional Requirements (for mixtures specified on a cubic yard basis) – Over thickness and over width will be waived at no direct pay.

Under thickness shall not exceed ¼ inch when determined in accordance with TR 602. For the final wearing course, areas with under thickness in excess of the ¼ inch shall be corrected to plan thickness at no direct pay. When grade adjustments are permitted, the contractor shall correct the area by furnishing and placing a supplemental layer of wearing course mixture meeting specification requirements over the entire area for the full width of the roadway. When grade adjustments do not permit, the deficient under thickness area shall be removed and replaced at no direct pay.

Under widths, as determined in accordance with TR 602, shall be corrected by furnishing and placing additional mixture 1 foot wide and plan thickness at no direct pay.

DOTD DISTRICT LABORATORY – VERIFICATION RESPONSIBILITIES

The district laboratory performs verification testing to ensure that the QC technician and DOTD personnel are using correct and accurate procedures, as well as proper equipment.

For HMA materials, the following verification tests are performed:

Sample	Tests	Frequency
Briquettes	Volumetrics	2 per lot
Pavement Cores	Density	2 per sublot

Verification samples must be delivered to the district laboratory in a timely manner so that the department inspector and the QC technician may study the total quality control process and be assured that the results of sampling and testing used for acceptance and control are valid and representative of the material.

The results of verification testing for HMA materials should be within the tolerances provided in the following table:

Test	Tolerance
Pavement Core	± 0.7 % of pavement density
V_a	± 1.0 % plant test results
VMA	± 0.5 % plant test results

If the results of verification tests are outside of these tolerances or the limits of the specifications, then the district laboratory engineer will notify the plant inspector immediately. It will be the joint responsibility of the project engineer and the district laboratory engineer to investigate the problem and, if necessary, to inspect both the process and testing equipment, and the actual testing procedures in use at the plant, followed by a notice of discrepancy when necessary.

The federally mandated Independent Assurance program requires that the district laboratory cut additional cores near the acceptance cores. It is necessary that station numbers appear on the project in accordance with Section 740, Construction Layout, and that the core holes are clearly identified on the pavement. For more information on Independent Assurance, refer to the *Materials Sampling Manual*.

In addition, as previously described, the district laboratory will perform verification analysis on asphalt cement and the Materials and Testing Section will perform acceptance testing.

EXAMPLE SUMMARY – APPLICATION OF PAYMENT ADJUSTMENTS

For the purposes of this example, it will be assumed that all test results and inspection procedures not covered by payment adjustments have met the requirements of applicable specifications.

Lot 105 = 5010 tons of Superpave Level I (19.0 mm NMS)

Plant Acceptance

1. V_a = 105.0 percent
2. VMA = 105.0 percent
3. Percent anti-strip = 98.0 percent

Therefore, the percent payment for plant acceptance is the average of percent payment for V_a, VMA and percent anti-strip additive:

Percent Plant Payment = (105.0 + 105.0 + 98.0)/3 = 102.7%

Note that the maximum percent payment for plant acceptance is 100 percent.

Roadway Acceptance

1. Pavement Density

Sublot 105-A	105.0%
Sublot 105-B	100.0%
Sublot 105-C	95.0%
Sublot 105-D	80.0%
Sublot 105-E	100.0%
Average	96.0%

2. Surface Tolerance = 100.0%

3. Therefore, the percent payment for roadway acceptance is the average of the percent payments for pavement density and surface tolerance:

$$\text{Percent Roadway Payment} = \frac{(96.0 + 100.0)}{2}$$

$$\text{Percent Roadway Payment} = 98.0\,\%$$

Note that the maximum percent payment for roadway acceptance is 100%

Total Payment

The percent payment for the Lot 105, 98.0%, is the lowest value of the percent payments for plant acceptance and roadway acceptance.

All calculations for percent payment shall be rounded to the nearest 0.1 percent.

The payment adjustments for asphalt cement properties will stand alone and will not be used in the individual lot calculations.

DEFINITION OF A LOT

Subsection 502.12 of the *Standard Specifications* defines a standard lot. When a plant produces mixture for only one project, the lot size and the tonnage delivered to the project will be identical. But, when a plant produces the same mixture for multiple projects, portions of each lot will be allocated to each project. Under the latter circumstances, the term lot will refer to that portion of the standard lot delivered to each project.

A standard lot is 5000 tons of consecutive production of hot-mix asphalt from the same job mix formula produced for the department at an individual plant. A sublot is 1000 tons. However, minor adjustments will be made in the 1000-ton sublot size to accommodate hauling unit capacity. When the total lot quantity is expended in the partial load of a truck, the full legal load of the truck will be included in the sublot. For example, if 988 tons of HMA are produced and sent to a project and the next truck hauls 24 tons, the actual sublot size will be 1012 tons (998 + 24).

All newly certified plants will begin production at standard lot size (5000 tons). However, when historical records indicate that an acceptable and uniform hot-mix is continuously being produced, **the standard lot size may be increased when agreed upon by the district laboratory engineer and the contractor/producer**. A standard lot will always have five sublots. Should the contractor/producer request an increase in lot size, then he should forward that request in writing to the district laboratory engineer. Twenty-four hour a day plant production usually necessitates such a request. In this case, it is preferred that the sublot size be increased to no more than 2000 tons to facilitate testing. Since these test results are necessary to ensure and monitor quality, they must be available in a timely manner. Once the expanded lot size has been established, it must be adhered to on a continuous basis. It is not intended that lot sizes be frequently and arbitrarily increased or decreased to meet short-term production changes. If the mixture being produced during the expanded-size lot operations does not meet department criteria or shows evidence or non-uniformity, the district laboratory engineer reserves the right to unilaterally reduce the expanded lot to the standard 5000-ton size. In addition, the expanded lot may be reduced to the standard 5000-ton size at any time by mutual agreement of the district laboratory engineer and the contractor/producer.

The sublot and lot number shall be indicated on each haul ticket. (The sublot and lot number may be either printed on the ticket via the printer system or written on the DOTD stamped form on the back of the ticket.)

The QC technician and DOTD inspector shall keep a running total of production to ensure that all sublots and lots are terminated at proper tonnage and that the succeeding lot number is placed on the next haul ticket. Lot numbers will be assigned based on total tons of plant production for a JMF. Lot numbers will be sequential to plant production for DOTD without regard to delivery points, individual projects or mix types. Therefore, lot numbers for an individual project could start at lot number 001 or at any lot number thereafter and will not necessarily be sequential on a project.

Sublot numbers will be designated with letters (e.g., Lot 105-C would represent the third sublot in lot 105).

The QC technician and DOTD inspector shall also maintain a written log of the distribution of hot-mix production for DOTD projects from a plant's operation. This log is to be kept in a numbered field book and shall contain, as a minimum, the following data:

Table Shown on Next Page

Sublot No.	Date	Project Number	Tons	Mix Type/ Use	Project Engineer	Remarks	JMF	% AC/Gmm	Initials
023-A	14 Aug	123-44-5678	1015.66	26/01	I. Schwartz	Tickets: 23-64	26.003	4.5% 2.503	C.V.J.
023-B	15 Aug	123-44-5678	1021.56	26/01	I. Schwarz	Tickets: 65-105	26.003	4.5% 2.505	C.V.J.
023-C	16 Aug	123-44-5678	1006.70	26/01	I. Schwartz	Tickets: 106-147	26.003	4.5% 2.506	C.V.J.
023-D	17 Aug	123-44-5678	1014.67	26/01	I. Schwartz	Tickets: 148-200	26.003	4.5% 2.502	C.V.J.
023-E	20 Aug	123-44-5678	1019.95	26/01	I. Schwartz	Tickets: 201-243	26.003	4.5% 2.505	C.V.J.
		Lot Total:	5078.54						
------------Control Charts are Up-To-Date ----------									

This log is to remain at the plant as a continuing record of plant production and distribution. It is to be maintained separately from all other department documentation. Notation shall also be made in the book to confirm that the Quality Control Charts are current. Lot numbers shall not be repeated until the plant has produced 999 lots.

The laboratory engineer or the QC technician may decide upon a smaller lot size based on any of the following conditions:

- The total interval between continuous production exceeds 2 days. This may include, but is not limited to, mechanical malfunction or inclement weather.
- A new job mix formula is approved and used. When an approved JMF proposal is used the previous lot will be terminated at existing tonnage.
- The quantity of HMA needed to complete the project is smaller than the lot size (e.g., the final lot is less than the lot size).
- A payment adjustment will be applied to the portion of the lot already produced, provided plant adjustments have been made to bring the HMA into compliance with the specifications and the JMF.

In the event of a smaller lot size, the HMA shall be accepted on the average values of the tests performed. It is not the department's intent that this specification be used to artificially manipulate the size of lots that will be assessed payment adjustments.

The final sublot on a project may be increased to within 150 percent of the stipulated plant sublot size. For example, if a plant were operating with 1000-ton sublots and the actual tonnage required to complete the project or phase, following production for the second to last sublot, is 1457, then the last sublot for the project would have 1457 tons. However, in this case, if the actual tonnage

required to complete the project is 1550 then two sublots would be required; one with approximately 1000 tons and one with 550 tons (adjusted for actual truck weights).

In addition, a lot shall be increased, for payment purposes, to six or seven sublots (at the end of a project or phase) to prevent a lot from having only one or two sublots for which PWL calculations cannot be completed in a statistically satisfactory manner. Advanced planning is required to determine the final number of sublots in the final lot. A final lot may have 3, 4, 5, 6, or 7 sublots.

Application of a Lot Portion to Paving Operations – It is noted that the number of days required to produce a lot is not significant. A lot may cover more than one day's operation. The lot number shall be assigned based on plant production. When mixture from a single lot is being delivered to more than one project, the tonnage for each individual project will be less than total lot tons. The applicable lot number will be used for each portion of the lot delivered to the projects.

The DOTD paving inspector will be responsible for coordinating the results of roadway tests (pavement density and surface tolerance) for each lot with the results of plant tests for that lot. The station limits per lane of each lot, as well as the total number of tons from each lot must be documented in both the project field book and the Superpave Pavement Report (Appendix AX).

Tests performed on material sampled at the plant will affect all projects receiving mix from the lot. Tests run on material sampled at the roadway will affect only the individual project. Pavement density (cores) and surface tolerance (on the final roadway or airport wearing course) will cause payment adjustments on the individual project. Volumetrics (V_a and VMA), as well as asphalt cement acceptance and the incorporation of the JMF required percentage of anti-strip, will affect all projects receiving HMA from a lot. Payment adjustments, if necessary, per project, will be based on both plant and roadway tests. Therefore, the roadway must use the same lot number as the plant for the portion of a lot placed on that project. This procedure will normally result in non-sequential lot numbers at the roadway.

An example of applying HMA materials to specific lots delivered to several projects simultaneously, is as follows:

A plant is producing Superpave Level I (19.0 mm NMS) Wearing Course HMA for three projects.

Lot 105-A	= 1010	tons
	506	tons to Project A
	463	tons to Project B
	41	tons to Project C
Lot 105-B	= 1020	tons
	710	tons to Project A
	310	tons to Project B
	0	tons to Project C

Lot 105-C	=	1008	tons
		406	tons to Project A
		292	tons to Project B
		310	tons to Project C

Accordingly,

Project A would show 506 tons matched to sublot 105-A, 710 tons to sublot 105-B and 406 tons to sublot 105-C.

Project B would show 463 tons matched to sublot 105-A, 310 tons to sublot 105-B and 292 tons to sublot 105-C.

Project C would show 41 tons matched to sublot 105-A, no tons to sublot 105-B and 310 tons to sublot 105-C. Under no circumstances would Project C, in this example, use the sublot number designation 105-B.

This HMA mix distribution shall be documented, on a daily basis, in the Plant Log Field Book as previously described.

PROVISIONS FOR SMALL QUANTITIES

The department allows for some modification of sampling and testing frequencies and equipment inspection and certification for projects whose total plan quantity of HMA is less than 1000 tons. These modifications are also permitted when the plan quantity of HMA is less than 1000 tons at separate locations on the same project. The separate location is defined as an area that is constructed in a stand alone phase and when the plant is producing HMA mixtures for only that project.

250 to 1000 Tons of HMA – For projects, or separate locations within a project, requiring between 250 and 1000 tons of HMA, one sample shall be taken for V_a and VMA for each 250 tons or portion thereof produced. Percent anti-strip shall be determined once. V_a, VMA and % anti-strip shall be documented on the QA copy of the Asphaltic Concrete Plant Report form (Appendix AW).

Five samples shall be taken for determination of pavement density, with the sampling distribution to be determined by the project engineer. Pavement density results shall be documented on the Superpave Pavement Report form (Appendix AX). Application of surface tolerance requirements shall also be at the discretion of the project engineer.

The following pay determination will apply.

Parameter	Tolerance	Percent Payment
V_a	3.0% to 5.0%	100%
V_a	2.0% to 2.9% and 5.1% to 6.0%	95%
V_a	Less than 2.0%	50
V_a	Greater than 6.0%	50% or remove
VMA	Within tolerance	100%
VMA	-0.1% to –0.9% of lower limit	95%
VMA	-1% of lower limit	50% or remove
Roadway Density	Within tolerance	100 %
Roadway Density	-0.1% to -0.9% of lower limit	95%
Roadway Density	-1% of lower limit	50% or remove

The % payment for plant acceptance will be the average of the % payment for voids, VMA, and anti-strip additive. The % payment for roadway acceptance will be the average of the % payments for density and surface tolerance.

For projects requiring between 1000 and 3000 tons, the table for "250 tons to 1000 tons" shall be used for each sublot. Each sublot will be paid individually. No verification testing will be required.

The project engineer or the paving inspector will inspect all paving equipment to be used on the project to ensure that it meets the requirements of the specifications and is operating properly. The equipment (asphalt distributor, spreader and rollers) does not require current certification stickers. However, equipment that does not produce a satisfactory mat shall not be allowed to operate on any DOTD project.

All HMA design requirements shall be in accordance with the requirements outlined in this manual.

The use of a material transfer vehicle (MTV) shall be at the discretion of the project engineer.

Less than 250 Tons of HMA – For projects or separate locations within a project requiring less than 250 tons, the JMF, materials, and plant and paving operations shall be satisfactory to the Project Engineer.

The project engineer may modify sampling and testing requirements for surface tolerance and pavement density and may waive the payment adjustment for deviations. No verification testing will be required.

The project engineer or the paving inspector will inspect all paving equipment to be used on the project to ensure that it meets the requirements of the specifications and is operating properly. The equipment (asphalt distributor, spreader, and rollers) does not require current certification stickers. However, equipment that does not produce a satisfactory mat shall not be allowed to operate on any DOTD project.

All HMA design requirements shall be in accordance with the requirements outlined in this manual.

The use of a material transfer vehicle (MTV) will not be required for projects, or separate locations within a project, having a plan quantity less than 250 tons of HMA.

> For example, a bridge replacement project with multiple sites has one site (of three) that has a plan quantity of 1540 tons. The other two sites had plan quantities of 450 and 786 tons, respectively. Therefore, for the bridge site where 1540 tons are specified all standard sampling, testing and equipment inspection and certification procedures shall be followed. At the other two sites, whose plant quantities are 450 and 786 tons, the small quantity modifications may be applied.

It is not the intent of the department that these modifications result in a product that does not conform to the requirements of the specifications. Therefore, all mixtures shall be produced at a certified plant; materials shall be from approved sources approved by the department and shall not exhibit any conditions or characteristics that could be deleterious to the compacted mixture.

The QC technician shall develop a Job Mix Formula and submit it on the Asphaltic Concrete Job Mix Release (Appendix AL) to the project engineer for approval.

JOB MIX FORMULA RESUBMITTALS

Should a QC technician submit a new JMF that is identical to a previously **approved** JMF except that a new source or type of asphalt cement is proposed (at the same proposed content), a new JMF is required. However, **only (a new Asphaltic Concrete Job Mix Formula form, (Appendix AL), along with moisture sensitivity analysis results, (AASHTO T 283) (Appendix V) is required for this rewrite submittal**. Note that no validation during the first 1000 tons of production are required for JMF “rewrites” with a only a change in asphalt cement grade or source. The validation data for the previously approved JMF may be used.

However, a moisture sensitivity validation will be required in accordance with T 283 during the first lot of production. This Lottman verification shall be conducted in the plant laboratory during the first lot of production. Results should be reported the on TSR Form (Appendix V) and forwarded to the district laboratory engineer in a timely fashion.

SUMMARY OF DOCUMENTATION

Asphaltic Concrete Plant Certification Report – The Asphaltic Concrete Plant Certification Report (Appendix A) is used to inspect the HMA plant for certification. In addition, a copy of the completed form is used for the 90-day inspections or intermediate inspections that are directed by the district laboratory engineer. An authorized representative of the district laboratory engineer completes two copies of this form. One copy is kept at the plant in the Plant Certification File. The other copy is forwarded to the district laboratory engineer.

Certification Report for Scales and Meters – This form will be provided by the department and can be obtained, along with all other DOTD documents, from the district laboratory engineer. This form is to be completed by an authorized representative of an independent scale calibration company (hired by the contractor/producer) and submitted to the district laboratory engineer. This form, whether completed for initial plant certification or for subsequent 90-day checks, shall be prepared in duplicate. One copy shall be retained in the Plant Certification File at the plant and the other is to be forwarded to the district laboratory engineer.

Asphaltic Concrete Paving Equipment Certification – District laboratory representatives use the Asphaltic Concrete Paving Equipment Certification forms (Appendices E, F and G) to document the certification of asphalt distributors, pavers, and rollers. This form is designed to be used as a complete package to certify the entire paving train or in parts for the certification of individual pieces of equipment. Copies of the certification forms for each piece of equipment certified in the district will be furnished to each project engineer in the district. Copies of equipment certification documentation will be supplied across district lines upon request to the certifying district laboratory engineer.

Asphaltic Concrete Paving Equipment Checklist – This form (Appendix I) is to be used by project personnel at the beginning of each project to document that all paving equipment used on the project (except for projects with less than 1000 tons or for projects with less than 1000 tons on separate areas within the project) is certified and is operating in accordance with the standards under which certification was granted. Copies of these checklists will be placed in the 2059 Review for the project on which the equipment was in operation.

This form is also to be used by the district laboratory representatives to document the ninety-day review inspections of certified equipment. It will be kept on file at the district laboratory with the original certification form and will be furnished to each project engineer within the district on a routine basis. Copies will also be made available across district lines upon request to the certifying district laboratory engineer.

Asphaltic Concrete Paving Miscellaneous Equipment Checklist – This form (see Appendix I) is to be used as a checklist by the DOTD inspectors to be certain that all miscellaneous equipment is available on the project and is in acceptable condition. It will also be included in the 2059 Review.

Job Mix Proposal (Release Form) – In order to submit a job mix formula to the department for approval, the QC technician must complete the Superpave Asphaltic Concrete Job Mix Release form (Appendix AK) (a computer generated form similar to the DOTD form may be used.) The following design data is required:

- A proposed blend summary with gradations and volumetrics at the proposed optimum asphalt cement content.
- Bulk Specific Gravity of each aggregate
- A plot of proposed composite gradation on the 0.45 power curve.
- A quantitative summary of three (minimum) trial blends.
- An optimum asphalt cement content summary for (V_a, VMA, VFA, % G_{mm} @ $N_{initial}$, % G_{mm} @ N_{design}, and % G_{mm} @ N_{max}).
- Coarse aggregate angularity (CAA) results – TR 306 double face.
- Fine aggregate angularity (FAA) results –TR 121
- Flat and elongated count (FE) results – ASTM D 4791.
- Sand equivalency (SE) results – TR 120
- Gyratory compactor test results for two samples prepared at optimum asphalt cement content for the proposed trial blend.
- Moisture sensitivity results – AASHTO T 283.
- Permeability results - ASTM PS 129.

The QC technician shall enter the proposed mix design data on the JMF Release form and sign and date the form in the space labeled "Submitted for the Contractor by." The technician shall then submit the form to the district laboratory engineer for initial approval.

The district laboratory engineer will check all submitted information. If any information is incorrect the district laboratory engineer will return the proposed JMF Release to the QC technician. If all information is correct and meets specifications the district laboratory engineer will assign the sequence number, mark the form approved, sign, and date it on the line labeled "Proposal Approved" and return the approved proposal to the QC technician. The plant will then be able to begin production for DOTD project for validation purposes.

Prior to sending any HMA mixture to a DOTD project, the QC technician shall forward a copy of the proposed JMF, either validated or invalidated, to the project engineer receiving HMA materials. (A facsimile copy will suffice.)

If the JMF is disapproved, the district laboratory engineer will mark the form disapproved, enter the MATT laboratory submitter code, sign and date the form, then return it to the QC technician and the project engineer receiving HMA materials. If the district laboratory engineer disapproves the JMF Release, the QC technician must submit a new JMF Release proposal. No additional mixture can be produced for DOTD projects until the district laboratory engineer approves a new JMF Release proposal for validation.

When the district laboratory engineer approves the JMF, it will be marked approved, entered into the MATT System with Submitter Code, signed (in the space labeled "Approved"), and dated. The form will then be returned to the QC technician and the project engineer receiving HMA materials. If the district laboratory engineer approves the JMF Release, the plant can continue operations for DOTD projects having the same specification requirements as the mix design. The mix design will be approved for separate projects on an individual basis. Following validation, the JMF Release must be assigned to those projects that receive mix produced from the JMF. The district laboratory engineer will then distribute copies of the JMF Release to the project engineer, the QC technician, the Materials Engineer Administrator, and the Construction Audit Unit. Once a JMF has been validated and approved, it may be used for other projects having the same specification requirements.

Asphaltic Concrete Gradation – 0.45 Power Curve(s) – The QC technician shall plot the proposed design gradation on the appropriate 0.45 Power Curve according the mixture's nominal maximum aggregate size (Appendices T, U and V). This gradation plot must accompany the JMF Release when submitted to the district laboratory engineer for initial approval. A computer generated gradation plot may be used in lieu of the DOTD supplied form.

Optimum Asphalt Cement Content – Summary of Test Properties – The QC technician shall submit the Summary of Test Properties form (Appendix AP) along with the JMF Release form and supporting design data, to the district laboratory engineer. A computer generated set of curves may be used in lieu of the DOTD supplied form. Plots of Va, VMA, VFA, percent G_{mm} at $N_{initial}$, and percent G_{mm} at N_{design} shall be graphed versus percent asphalt cement as determined from the trial blends. % G_{mm} @ N_{max} must be shown to meet specification requirements.

Tensile Strength Ratio (TSR) The QC technician shall submit the Tensile Strength Ratio (TSR) form (Appendix V), along with the JMF Release form and supporting design data to the district laboratory engineer. A computer generated TSR form may be used in lieu of the DOTD supplied form. Careful attention should be made to the calculations required, via AASHTO T 283, for degree of saturation.

Superpave Asphaltic Concrete Plant Report – The Superpave Asphaltic Concrete Plant Report (Appendix AW - 2) is a MATT System form. It is to be completed based on plant sublot and lot. Space has been allotted on the form for individual project number entry since the results of plant testing per lot will apply to each project receiving HMA mixtures from the lot. Therefore, it is imperative that each project to which mix is delivered from a lot be recorded on the form. It is the joint responsibility of the QC technician, the DOTD inspector, and the district laboratory to complete and sign this report.

The completed Plant Report is to be sent to the district laboratory engineer with the Asphaltic Concrete Verification Report (Appendix AZ), the gyratory briquettes (one per sublot) and roadway pavement cores (two per sublot) for verification testing. The Plant Report, when filed with the Superpave Pavement Report (Appendix AX), will complete documentation for acceptance of the HMA lot.

An original and one copy of each plant report must be completed for acceptance. The signed original shall be sent to the district laboratory. The copy shall be kept in the plant files. The district laboratory engineer's representative will review the information for completeness and accuracy and sign the form on the line labeled District Laboratory. The district laboratory engineer will then review the information and approve the form by signing in the line labeled "Approved By" before the information is entered into the MATT

System. The MATT System will then generate a logging report for each project. The district laboratory will keep the original of the Plant Report. Copies will be sent to each project engineer receiving mixture from the lot.

Asphaltic Concrete Control Charts – These charts shall be completed by the QC technician as testing is completed. They are to be maintained on a lot or running average basis. **Control Charts shall be plotted for maximum theoretical gravity of the HMA mixture (G_{mm}), %G_{mm} @ $N_{initial}$, and G_{mb} @ N_{max}.** There is space for up to three entries per lot on each graph. Corrective action taken for deficiencies (or to bring the production process closer to median values) shall be documented, dated and initialed on the back of the Control Chart by the QC technician. The Control Charts are to be kept at the plant. A copy of the Control Charts is sent to the District Laboratory at the end of each project. A copy of the DOTD Control Chart form is shown in Appendix AC. A computer-generated form may be used in lieu of the DOTD supplied form.

Superpave Pavement Report – The Asphaltic Concrete Pavement Report form (Appendix AX) **will be completed for each mix use for each type mix for each project**. This will result in only one pay item being recorded on each form. The DOTD Certified Paving Inspector is responsible for the completion of this form, with the exception of roadway density data and corresponding percent pay information that is determined at the plant. The DOTD Certified Plant Technician will complete these sections. The DOTD Certified Paving Inspector will sign and date the form in the space labeled "Roadway Inspector." The Pavement Report, when filed in conjunction with the Asphaltic Concrete Plant Report, will complete documentation for acceptance of the pavement lot.

An original plus two copies of this form must be generated. The DOTD paving inspector will retain one copy for project records. The original and one copy are to be sent to the DOTD plant technician with each set of pavement cores. The DOTD plant technician will complete both copies of the form with pavement density information and percent pay, then sign and date the form on the line labeled "Plant Inspector." The original will then be sent to the district laboratory with the other completed copy retained for the plant files. A district laboratory representative will review the form upon receipt for completeness and accuracy, initial and date it in the upper right corner, enter the information into the MATT System and copy the form for use during verification testing. The original will then be sent the project engineer receiving mixture for the lot for approval, signature, project records, and 2059 submittal.

Any disposition of failing results or payment adjustments must be noted in the "Remarks Field" by the project engineer and returned to the district laboratory engineer for MATT System update. The district laboratory will then update the MATT System, copy the updated Asphaltic Concrete Pavement Report for laboratory files and then return the original to the project engineer. The district laboratory will keep a copy of the updated report in the Disposition of Failing Test Reports file.

Asphaltic Concrete Verification Report – The district laboratory uses this form (Appendix AZ) to report the results of Independent Assurance tests and verification tests on samples submitted by project personnel.

The DOTD plant inspector will complete an original and one copy of the Verification Report. The original will be attached to the gyratory briquettes that are submitted to the district laboratory for verification testing. Before sending the form to the district laboratory with the briquettes, the technician will enter the “Header” information and sample ID for the volumetric tests along with the G_{mm} determined for the corresponding sublot. All samples ID’s will consist of the lot (and sublot) number plus sample number as identified by the plant and paving inspectors. The Verification Report and briquettes are to be sent to the district laboratory along with Asphaltic Concrete Plant Report.

The DOTD paving inspector will complete an original and two copies of the Verification Report for each set of pavement samples sent to the plant for acceptance and testing. The original and one copy of the report must accompany the samples. The paving inspector will retain the second copy for project records. The paving inspector shall complete the header information, Roadway Tests and Sample ID.

After completing plant tests on the pavement samples, the DOTD plant inspector will forward the two of the five samples to the district laboratory for verification testing. All sample ID’s shall consist of the lot (and sublot) number plus sample number. The inspector will then attach the original Verification Report to the original Pavement Report which accompanies the pavement samples to the district laboratory.

The district laboratory will use these forms (Plant and Roadway information) to enter complete verification information into the MATT System. The MATT System will then generate a single logging report for the project engineer’s records. If problems are encountered during the verification process the district laboratory will send copies of the Verification Report to the project engineer.

Ticket for Hot-Mix Asphalt – All quantities (truck loads) of hot-mix asphalt materials delivered to DOTD projects shall be recorded on printer tickets, which are stamped on the back with the departmental stamp.

This stamped printer ticket is given to the driver of the certified haul truck. The driver, upon arriving at the paving site, will turn over this ticket to the DOTD paving inspector. The paving inspector is responsible for completing and signing the lower portion of the stamp.

Since lot numbers may not necessarily be sequential for a specific project, it is imperative that the number assigned to each ticket be sequential for each project for each mixture type. This number will include both lot number and sequential project ticket number.

As a minimum, the HMA ticket shall show the following information:

- Project Number
- Date
- Lot and Sublot Number
- Ticket Number
- Truck Number (DOTD Certification Number for truck)
- Mix Type